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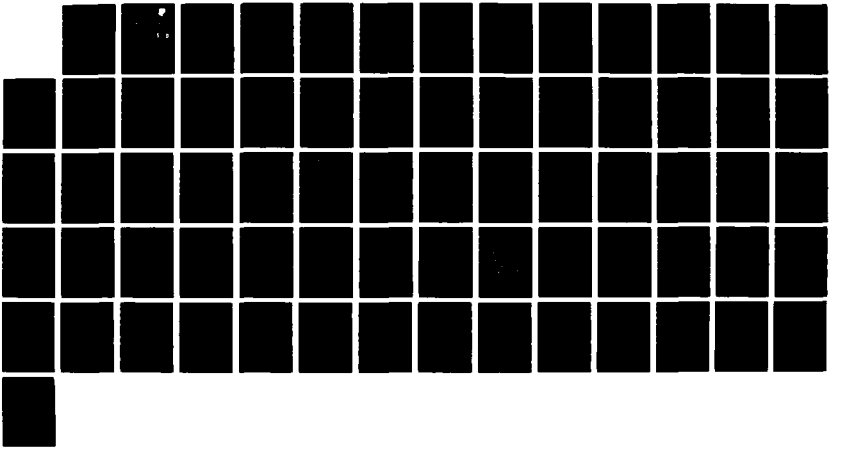

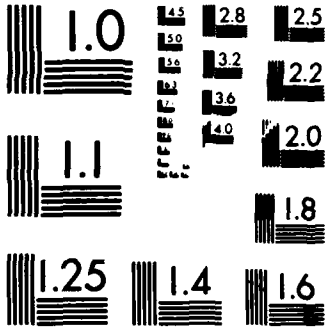

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DATA & ANALYSIS CENTER FOR SOFTWARE

IIT Research Institute

Karen Henniger

ROME AIR DEVELOPMENT CENTER
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The report discusses the operation and enhancements of the Data & Analysis Center for Software during the period from December 9, 1982 to April 8, 1986. Descriptions of the Software Life Cycle Empirical Database and the scientific and technical information database are provided. This report contains information on the types of services provided by the DACS, products developed during the period and the technical inquiries received relating to Software Technology. Special studies performed for DACS users on software technology problems and issues are also described.

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1.0 INTRODUCTION

1.1 BACKGROUND

The Air Force recognized the need for an information analysis center to serve the government, industrial, and university communities as a focal point for software development and experience data in the early 1970s. In 1976 the Rome Air Development Center (RADC) contracted with IIT Research Institute (IITRI) to design a center that would acquire, analyze, synthesize, and disseminate information on software engineering technology. Subsequently, in August of 1978, RADC contracted with IITRI to develop such a center, which was named the Data & Analysis Center for Software (DACS). The activities, accomplishments, and history of the development of the DACS during its 36-month pilot period from August 1978 through August 1981 were reported in RADC-TR-81-385, Establishment of the Data and Analysis Center for Software.

The DACS was designated a Department of Defense (DOD) Information Analysis Center (IAC) in January 1981 while still in its pilot period. At the end of the 36-month pilot period, IITRI was awarded a contract to operate the DACS for an additional 14-month period. The primary focus of this effort was to provide an orderly transition from a pilot information center to a full scale IAC and from a center completely supported by government funds to an IAC whose users are required to contribute to the support of those functions from which they obtain benefit. The activities performed during the transition period were reported in RADC-TR-83-132, Data and Analysis Center for Software: An IAC in Transition.

IITRI was awarded the current 36-month contract in 1982 to continue operating the DACS as a full-scale IAC. The contract was amended to extend the performance period to 40 months. This report addresses the activities of the DACS from 9 December 1982 to 8 April 1986, the current contract period.

1.2 OBJECTIVES OF THE DACS

The DACS was established to serve as a focal point for software development and experience data; for the analysis, synthesis and

dissemination of this data; and for scientific and technical information (STINFO) concerning the field of software engineering. As implemented, the DACS provides a centralized authoritative source for current, readily usable data and information concerning software technology. The objectives of the DACS are to:

- Encourage the exchange of software technology information among DOD and civil government agencies, government contractors, the private sector and academia
- Support software technology research by providing a centralized source of software life cycle data
- Increase the productivity of software producers and the quality of the resultant computer software by improving the transfer of software engineering technology
- Assist in diffusing new technology throughout the U.S. industrial base, thereby expanding its capability and competitive posture
- Provide scientific and technical information analysis services to DOD, civil agencies, government contractors, and the private sector in areas relating to software technology needs, developments, and trends
- Minimize duplication of software technology research

Specific objectives for improving the DACS during this reporting period included:

- Expanding the role of the DACS in the software engineering community
- Increasing the quality of Scientific and Technical Information (STINFO) acquisition
- Improving life cycle data acquisition and analysis capabilities
- Increasing the automation of routine DACS procedures
- Expanding and promoting special studies capabilities

1.3 REPORT CONTENTS

Activities of the DACS described in this report were performed with the above objectives in mind. This report contains 11 sections which summarize the DACS activities during the contract period extending from 9 December 1982 to 8 April 1986. A brief description of the topics covered in each section follows.

Section 1.0 Background and objectives of the center.

Section 2.0 Summary and technical progress and activities involved in the operation of the center.

Section 3.0 Descriptions of the data acquisition program and the DACS Software Life Cycle Empirical Database.

Section 4.0 Description of the Scientific and Technical Information Database.

Section 5.0 Discussion of the DACS data analysis program and related efforts.

Section 6.0 Summary of the current awareness program, including newsletters, bulletins and technical presentations.

Section 7.0 Discussion of various DACS products and services, including data subsets, data compendiums, state-of-the-art reviews, bibliographic and tool searches, and consulting services.

Section 8.0 Presentation of new DACS products and services, along with a discussion of improvements of products and services.

Section 9.0 Discussion of promotional advertising to new users by use of free publicity and presentations at conferences and symposia.

Section 10.0 Synopses of the fourteen DACS special efforts performed during this contract period.

Section 11.0 Observations and recommendations.

2.0 TASK 1 - OPERATION AND MAINTENANCE OF CENTER

2.1 SUMMARY OF GOALS, TECHNICAL PROGRESS AND ACTIVITIES

2.1.1 Goals Set for the DACS

The activities of the DACS during this period were oriented toward:

- Disseminating state-of-the-art information on software technology of general interest to the software engineering community
- Conducting a user awareness program through publication of newsletters and bulletins, presentations at professional seminars and at the sites of potential clients, and active participation in professional and technical organizations
- Preparing and distributing products and services designed to meet the information needs of the DACS user community
- Preparing a compendium of software engineering standards to include military, civil government and voluntary standards
- Maintaining and expanding the Software Life Cycle Empirical Database (SLED), containing data which is descriptive of the development and maintenance process of a variety of software projects
- Maintaining and expanding the STINFO database to provide up-to-date research materials from which the products and services of the DACS are to be developed and to have available the most recent information to supply to users
- Expanding the Software Tool Information (STI) database, offering custom tool searches to DACS users
- Expanding the scope of data analysis activities and disseminating the results of analysis activities to the software community in a readily usable form
- Continuing and expanding the promotional program so that the maximum number of potential users of DACS products and services are made aware of their existence
- Continuing solicitation of user feedback on the products and services offered by the DACS to ensure that they will continue to provide the greatest possible usefulness to DACS users
- Tracking and tabulating of user interactions with the DACS so that the optimum mix of products and services may be provided to the persons and organizations who support the DACS through the purchase of its products and services

2.1.2 Summary of Activities Accomplished

The following paragraphs briefly summarize the major accomplishments of the DACS during this contract period.

The Software Life Cycle Empirical Database (SLED) software was enhanced to include automatic generation of tapes and listings for three additional datasets. Using the parameterized software, the Independent Verification and Validation (IV&V) Dataset, the NASA/SEL Dataset and the Composite Productivity Dataset can be produced by clerical personnel. Additional productivity data has been added to the DACS Productivity Dataset, and the DACS obtained three new datasets for the SLED.

The review of several technical reports on data collection and a study of the SLED documentation led to the production of the DACS Data Collection Package. This package includes forms for the collection of software engineering measurement data.

A new data analysis plan was developed based on the plan produced under the previous contract, and selections were made from the suggested data analysis tasks described in the plan. The Baselines Analysis Task has been a continuing project during this contract period, and four baseline progress reports were produced. The reports entitled "A Comparative Study of Parametric and Non-Parametric Statistical Procedures in the Analysis of Software Engineering Data," and "A Simulation Methodology for Software Engineering Analysis" were also produced.

The on-line bibliographic database was expanded to over 6,000 documents. New software was developed to automate and streamline input processes, and the custom searches were enhanced in both appearance and information content. The data definition for the software tool information database was changed to reflect new data items, and existing data was restructured to coincide with the new data definition. Additionally, the applications software for the database was enhanced. Information on 224 new tools was added to the database.

The DACS produced and distributed 13 newsletters and 26 bulletins as part of the current awareness program. In addition, the DACS staff presented papers at conferences and gave presentations at the sites of potential clients. The DACS also responded to publicity questionnaires for free advertisement of its products and services. Finally, several new promotional fliers and brochures, which outline many of the DACS products and services, were produced and distributed.

User fees during this contract period averaged $2,708 per month. The total number of technical inquiries processed was 2,452, which significantly increased the monthly technical inquiry average when compared to the last reporting period.

Fourteen special study efforts were negotiated and implemented at the DACS during this contract period. Each of these projects is discussed in Section 10.0.

3.0 TASK 2 - ACQUISITION OF SOFTWARE EXPERIENCE DATA

3.1 INTRODUCTION

There is a real need to collect productivity and failure data on the development, operation and maintenance of software to support research in the software field. Data is needed which will allow researchers to isolate the factors that contribute significantly to the costs, reliability and quality of the software, to measure achieved reliability, to predict development and maintenance costs, and to track the progress of a software development project. This section contains descriptions of the DACS data acquisition program and the resultant DACS Software Life Cycle Empirical Database (SLED).

3.2 DATA ACQUISITION APPROACH

The means used to maintain the data acquisition program consisted of:

- Identifying data sources and acquiring relevant data
- Establishing procedures for automatic submission of data
- Establishing procedures for processing and evaluating, and for database entry
- Maintaining the computer database

These procedures were documented at length in RADC-TR-81-385 (CAR082) and will not be reproduced here; the reader is referred to this document for full details.

3.3 SOURCES IDENTIFIED

The DACS has made numerous inquiries during this contract period, with the intention of ascertaining the availability of software data. The inquiries included reviewing data sources (primarily Commerce Business Daily (CBD) announcements), contacting potential data sources, and initiating follow-up activities associated with these data sources. The acquisition activities, along with meetings conducted to discover additional data sources, resulted in significant new datasets for the SLED:

- The DACS Productivity Dataset contains project level data on over 500 projects
- The Reliability Dataset contains data on over 2,800 failures from 16 projects
- The NASE/SEL Dataset contains very detailed data on over 30 projects conducted by NASA's Goddard Space Flight Center
- The Verification and Validation (V&V) Dataset contains data on almost 1,000 anomaly reports from five software projects
- The Architecture Research Facility (ARF) Error Dataset contains data on 117 errors from a system with 253 modules; the dataset also contains module descriptive data
- The Baseline Software Dataset (BSDS) contains problem report and module data on six large software projects
- The PAVE Phased Array Warning Systems (PAWS) Operations and Maintenance (O&M) Dataset consists of data collected by the Program Support Library on the PAVE PAWS system
- The NASA/Ames Dataset contains data on over 3,700 software problem reports from about 35 projects
- The DACS Composite Productivity Dataset contains data from the DACS Productivity Dataset, the NASA/SEL Dataset, and the V&V Dataset; the composite dataset explored the prospects of unifying all DACS datasets

3.3.1 Automatic Submission of Data

Automatic generation of data for the PAVE PAWS and NASA/SEL Datasets is continuing. The DACS receives updated data on tape from the PAVE PAWS programming agency once a month, and NASA/SEL sends updated data on tape approximately once a year.

3.4 ACCOMPLISHMENTS OF THE DACS SOFTWARE LIFE CYCLE EMPIRICAL DATABASE (SLED)

DACS personnel expanded the SLED by 114 projects, 69 of which were added to the DACS Productivity Dataset as a result of a literature search. The

remaining 45 projects were generated by aggregating NASA/SEL data at the system level and were also added to the DACS Productivity Dataset.

The SLED was implemented on the RADC HIS 870 computer system, using Honeywell's Management Data Query System (MDQS) to facilitate the management, manipulation, preparation and analysis of the data. Software was written to allow clerical personnel to produce tapes and hardcopies of the SLED datasets. This software greatly reduces the time needed to process orders for these datasets.

DACS personnel also corrected various anomalies in several of the datasets and/or the documentation. Finally, the DACS continued its program of automatically collecting updated data from both NASA/SEL and the PAVE PAWS programming agency.

3.5 CURRENT STATUS OF THE DACS SLED

The DACS SLED currently consists of nine sets of data distinguishable by data source, data collection and acquisition methodology, life cycle phase represented, and data parameters present. Because each set of data was the result of a data collection effort that pursued individually specific objectives, the resulting datasets differ with regard to:

- o The time period represented by projects in a dataset
- o The portion of the software life cycle represented by the data
- o The aspects of the software development and/or maintenance processes measured by the data collection activity
- o The quality of the data as reflected in the verification and validation procedures used in data collection
- o The subsequent analyses supported by the data

The nine data sources associated with the SLED are listed below. Complete descriptions of the datasets can be found in the references provided.

(1) The DACS Productivity Dataset - data collected from various government and private industry sources and complied by Richard Nelson of RADC (NELS78)

(2) The Reliability Dataset - data collected at Bell Laboratories, Whippany, N.J. and complied by John Musa (MUSA79)

(3) The NASA/SEL Life Cycle Dataset - data collected and contributed by the Software Engineering Laboratory (SEL) at NASA Goddard Space Flight Center (BASI79)

(4) The Verification & Validation (V&V) Dataset - data collected under several Independent V&V contracts then summarized and delivered to the DACS by Logicon Incorporated (RADA81)

(5) The ARF Error Dataset - data collected and analyzed on the development of the Architecture Research Facility (ARF) at the Naval Research Laboratories (NRL) by David Weiss (ELOV79)

(6) The Baseline Software Dataset (BSDS) - data collected on (DUVA79I,DUVA79II)

(7) The Operations and Maintenance (O&M) Dataset - data collected on the operations and maintenance of the PAVE PAWS Phased Array Warning System (IITR82)

(8) The DACS Composite Productivity Dataset - data combined from the DACS Productivity, NASA/SEL and IV&V datasets as part of feasibility study into streamlining the SLED (TURN82)

(9) The NASA/Ames Dataset - data on over 3,700 software problem reports from approximately 35 projects

When analyzing data of this nature, it is important to consider that the datasets were generated at different points in time. Figure 3.5-1 illustrates the periods of time represented by data in each of the datasets. Each of the datasets contains data from various software life cycle phases as depicted in Figure 3.5-2. Of these nine datasets, six are available in a standard format. The remaining three, the ARF, BSDS, and O&M datasets, because of their extensive nature, have not been processed into a form which is readily usable, which limits distribution to customized versions of these datasets. Each of the nine sets of data is discussed in detail in The DACS Data Compendium (TURN82).

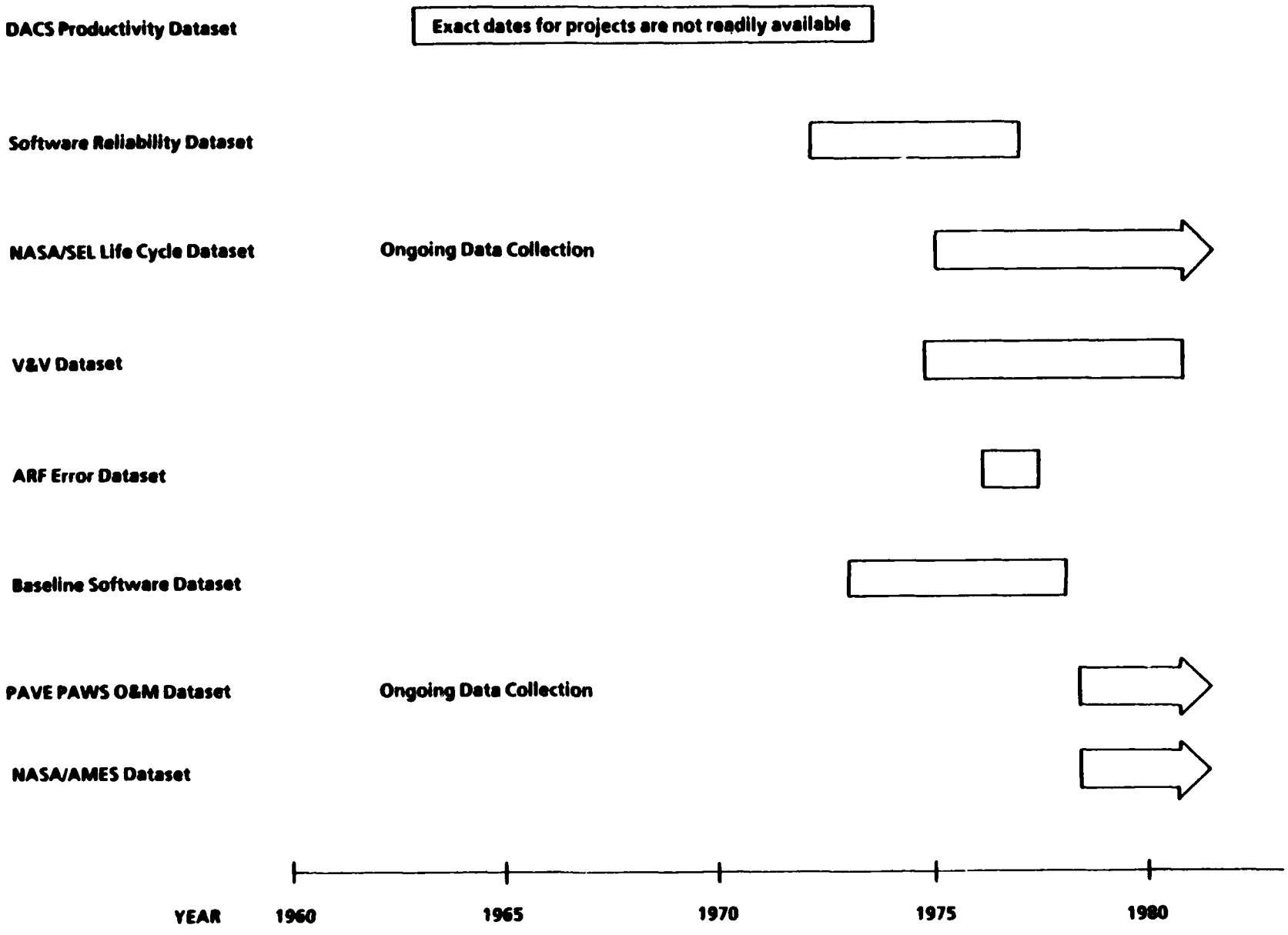

Figure 3.5-1. Time Periods Represented by SLED Datasets

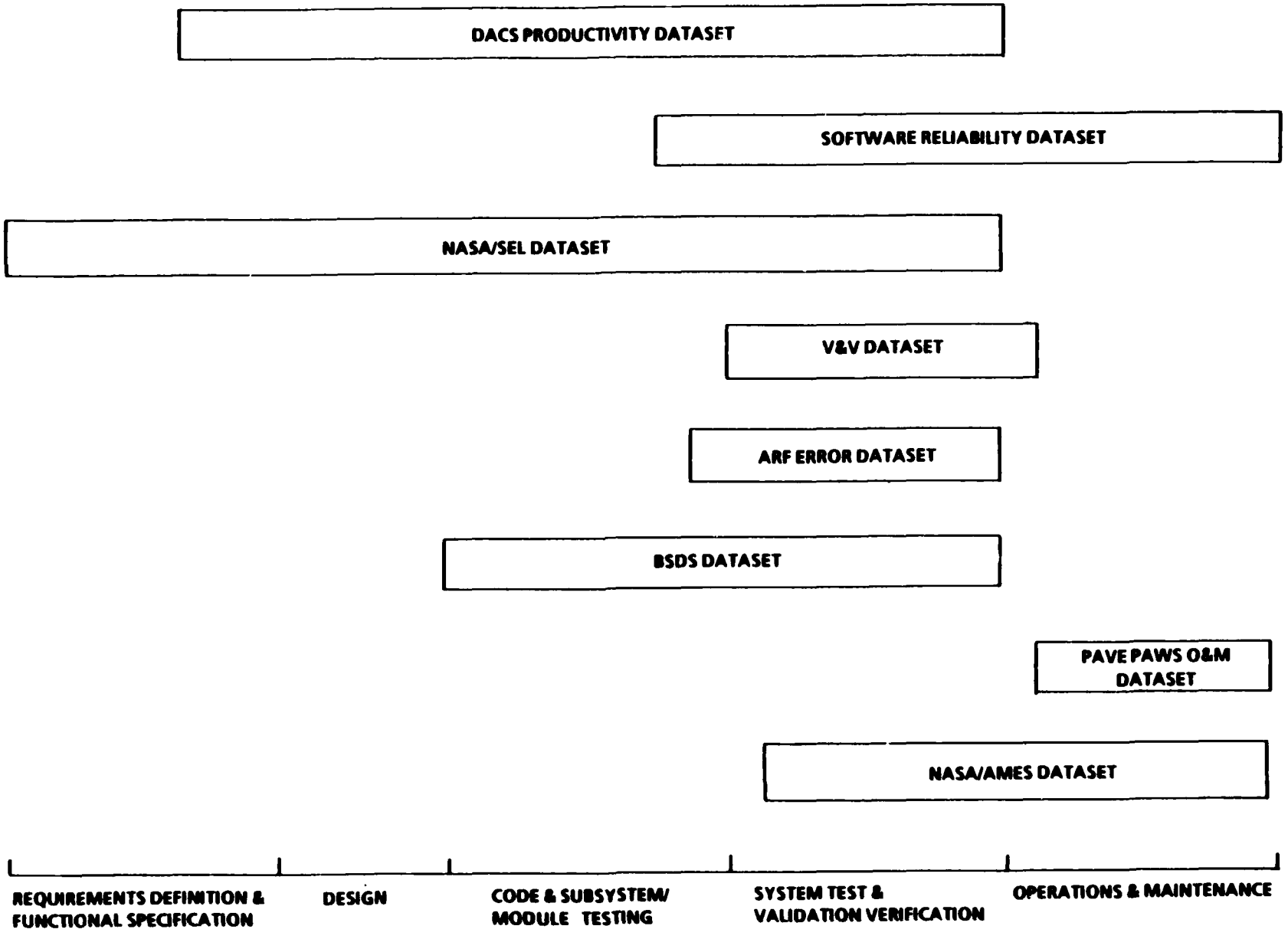

Figure 3.5-2. Life Cycle Phases Described by DACS Datasets

4.0 TASK 3 - SCIENTIFIC AND TECHNICAL INFORMATION (STINFO)

4.1 INTRODUCTION

Scientific and Technical Information (STINFO) consists of documented information concerning the state-of-the-art and technology aspects of the computer software field. STINFO usually includes technical reports, trade journal publications, proceedings of conferences and symposia, theses, texts, and product descriptions and specifications. Table 4.4-1 shows the sources from which the software engineering documents are identified. Also included as STINFO are descriptions of ongoing software technology research for which reports may not yet have been produced. These two types of STINFO serve as input to three information databases maintained by the DACS: the Software Engineering Bibliographic (SEB) Database, the Software Engineering Research Projects (SERP) Database, and the Software Tool Information (STI) Database.

4.1.1 The Software Engineering Bibliographic (SEB) Database

The SEB Database was established to provide a readily accessible source of comprehensive information of the state of the art in software engineering, as well as a means of channeling that information to those people in the software engineering community who can make use of it in their day-to-day activities of developing, maintaining, and managing software. The bibliographic collection is composed of texts, technical reports, theses, journal articles, proceedings and other documents relating to software engineering, reliability, costs and quality factors, maintainability, and other topics deemed appropriate. The collection is computer-accessible and retrieval of document information can be made on any part of the document citations or on assigned keywords.

New software for the SEB Database was written to automate the input process and the error checking process. Also, the existing software was modified to accommodate the addition of a new field which determines the document processing status. The addition of this field allows the entry of incomplete summarized documents into the database and eliminates a separate

TABLE 4.1-1. SOFTWARE ENGINEERING DOCUMENTS ARE IDENTIFIED FROM MANY SOURCES

Source of Document	Type of Document	Identification Method
U.S. Government Nat'l Technical Information Service (NTIS)	Unclassified gov't reports prepared by gov't agencies and their contractors or grantees	Regular review of publicizing instruments NTIS Technical Notes
Defense Technical Information Center (DTIC)	Classified or limited distribution reports on R&D done by DoD or its contractors	DTIC Technical Abstracts Bulletin
General Accounting Office	Investigative reports on activities of government agencies	DACS is on distribution for reports pertinent to software technology
Naval Publications and Forms Center	DoD standards, regulations and specifications	Catalog
RADC	Technical Reports	Distribution list
Professional Society	Papers Conference proceedings, journals, tutorials	Membership in Society Attendance at selected conferences, workshops, symposia Review catalogs of publications
Publisher of Periodicals directly relevant to software engineering	Journal articles, papers	Subscription
Publisher of Texts	Texts	Catalog or announcement or book review in professional journal
Colleges and Universities	Theses and Dissertations	Periodic review of Dissertation Abstracts by University Microfilms
Information Retrival Services	Papers, conference proceedings, journals, tutorials	Subscription

in-process database. Streamlining the SEB Database resulted in a significant reduction of clerical time required for document processing. During this contract period 2,725 documents were added to the SEB Database. Figure 4.1-1 displays the composition of the SEB Database.

4.1.2 The Software Engineering Research Projects (SERP) Database

The DACS maintains the SERP to provide a computer-accessible source of information about recent and ongoing research in the field of software engineering. Projects covered in this database are those involving software technology research, such as the development or evaluation of programming languages, models or software tools, and research related to software engineering methodologies, such as modern programming practices. The database was developed during the pilot period and was refined during the transition period of the DACS operation.

4.1.3 The Software Tool Information (STI) Database

The National Bureau of Standards (NBS) developed a software tools database which contained information on 250 software tools. NBS could no longer support this database and was seeking a new facility which could support its tools database and make it available to the software engineering community. Recognizing the need for a central source of software development tool information, the DACS acquired NBS's Software Development Tools Database, which formed the foundation for the STI Database.

The STI Database was updated during this contract period. Requests for current information on the tools were sent to all sources that were used in the initial database development. Responses received were used to delete tools that were no longer available and to modify, correct and add information on other tools.

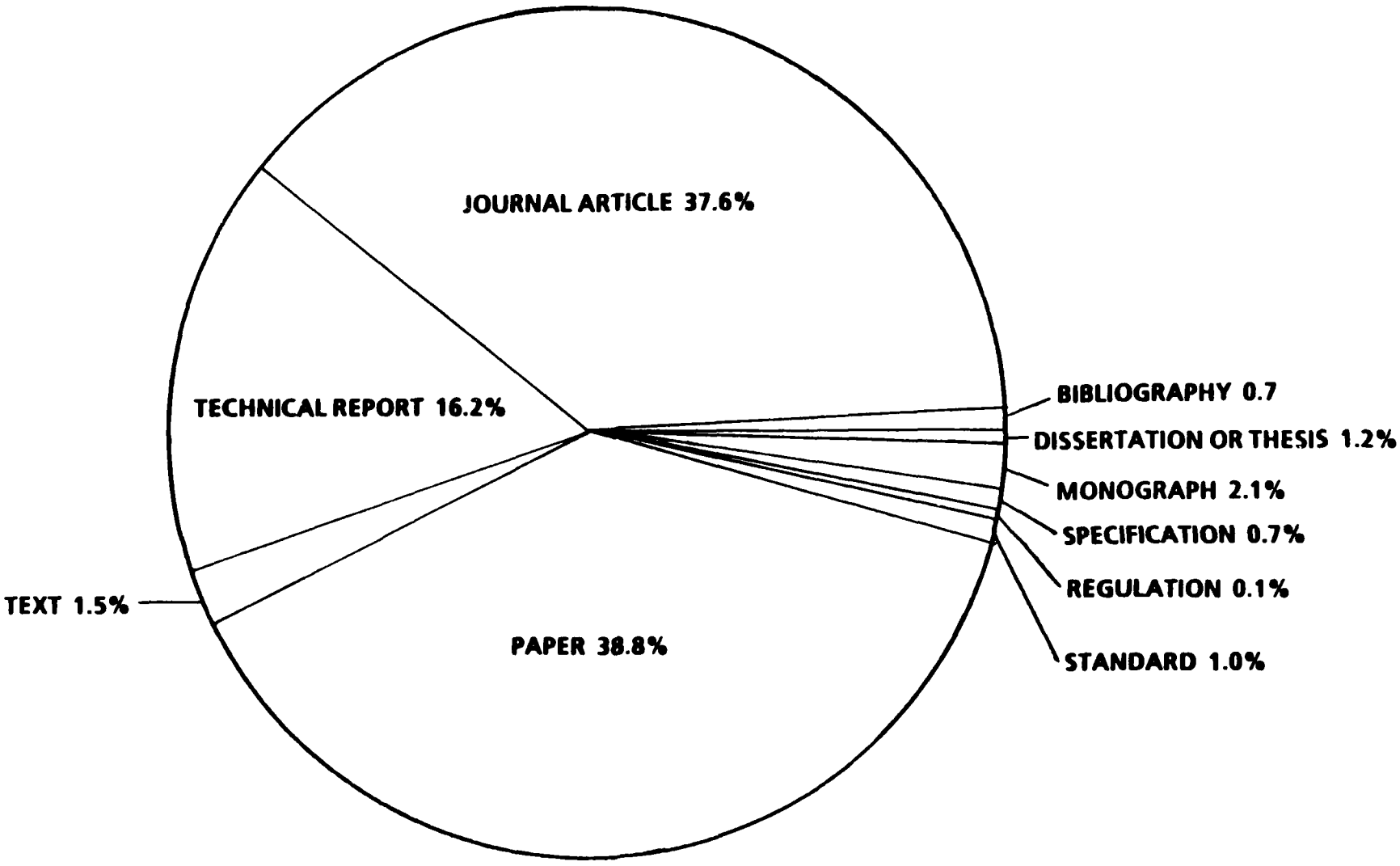

Figure 4.1-1. The Software Engineering Bibliographic Database (SEBD) Contains a Variety of Document Types

To facilitate the collection of information on new software development tools, the DACS developed Software Tool Description Forms. These forms are used in conjunction with an information acquisition program implemented specifically for identifying and acquiring information on new software development tools. DACS personnel produced the Software Life Cycle Tools Directory, which is distributed as a DACS product.

The activities associated with updating the STI Database and acquiring new tool information for the database resulted in approximately 224 new tools being added, 53 tools being deleted and 24 tools being updated. Table 4.1-2 displays a breakdown of the types of tools in the STI Database.

TABLE 4.1-2. STI TOOL TYPES.

Tool Class	Number in This Class
Software Management Control & Maintenance	132
Software Modeling & Simulation	15
Requirements and/or Design Specification & Analysis	57
Source Program Analysis & Testing	117
Program Construction & Generation	50
Software Support System/Programming Environments	50
Total Number of Tools	421

5.0 TASK 4 - DATA ANALYSIS PROGRAM

5.1 INTRODUCTION

The DACS contributes to software technology research through data analysis, as well as through special studies, state-of-the-art reviews, and technology assessments. The first data analysis program plan was initiated in 1981. During the current reporting period, a second data analysis program plan was produced by J. Romeu of the DACS (ROME83), which builds on and further develops the initial plan.

These data analysis efforts provide input for long-term research and development objectives, which include:

- Providing a better understanding of the processes involved in producing, managing and maintaining software
- Identifying those factors which influence the cost quality, reliability and complexity of software
- Developing and improving methods and tools for use in producing and maintaining software
- Applying or developing new tools for the data analysis effort
- Developing techniques for estimating costs, resource requirements and schedules of future software products and methods for predicting the reliability of those projects
- Developing techniques to assist managers in planning, measuring, and tracking of development and maintenance of software projects

This section provides an overview of the data analysis program plan and discusses the research and development efforts which resulted from this task.

5.2 OVERVIEW OF THE DACS DATA ANALYSIS PROGRAM PLAN

The purpose of the Data Analysis Program Plan for the DACS (ROME83) was to outline a set of analysis tasks which could be performed at the DACS. The SLED served as primary input to all the analyses outlined in the plan. Figure 5.2-1 shows the analysis process that is carried out for each investigation.

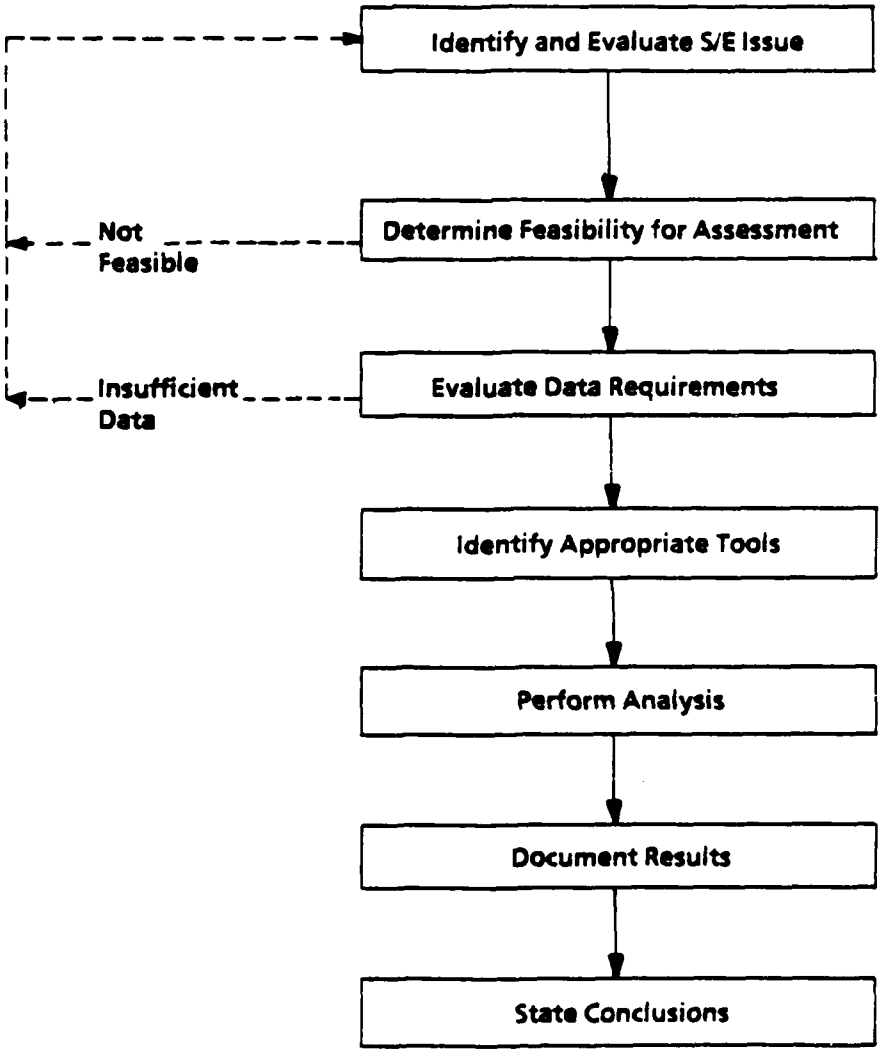

Figure 5.2-1. Analysis Process

Experience with previous data analysis tasks permitted a better assessment concerning the availability and reliability of the data in the SLED Database and in turn made it possible to define areas in which more relevant or useful results could be obtained. New topics and areas to which future analysis could be directed were also derived from previous analysis experience.

The plan delineated four major topic areas:

(1) Environment and Technology Studies

(2) Cost Study

(3) Baseline Analysis Activities

(4) Technical Monographs

The Environment and Technology Studies consisted of both research and development tasks. One effort was chosen from each of the task areas in the Environment and Technology Studies.

5.3 DATA ANALYSIS EFFORTS

During this contract period the DACS performed several data analysis projects which established procedures, methods, and routines that support the investigation of software metrics, provide data summary, and assess and compare software engineering tools and methods.

DACS personnel developed two dataset evaluation metrics, INTEGRATION and COVERAGE, which are used to determine the adequacy of the data in one of the SLED datasets, to do comparisons across a variety of projects, and to determine if the database contained data elements, as required by the various software reliability models and other analytical techniques.

The DACS Data Compendium, which describes the SLED datasets, the data items contained in them, and high level summaries of the datasets, was produced and was updated to reflect changes made to the SLED during this contract period.

An evaluation of equivalent parametric and nonparametric statistical tests was performed with respect to their appropriateness for analyzing software engineering data.

For much of this contract period, ongoing data analysis performed by DACS personnel produced software baselines from the SLED NASA/SEL dataset. These baselines show how:

- Development resource use varies with the size of the module
- Subjective estimates of complexity are reflected in more objective variables of size and resources expended
- More precise specifications lead to less complex tasks and to the use of fewer resources
- Estimates change during the course of the life cycle

6.0 TASK 5 - CURRENT AWARENESS PROGRAM

6.1 INTRODUCTION

The current awareness program was maintained and enhanced throughout this report period. The program has two purposes: (1) to keep the DACS user community informed of the latest and most significant developments in software technology and software engineering, and (2) to inform its current user community and potential users of the products and services offered by the DACS, as well as the benefits to be realized through use of the DACS. The DACS implements the current awareness program in the following ways:

- Publication of the DACS Newsletter
- Publication of the DACS Bulletin
- Presentations at conferences and symposia
- Establishment of contacts throughout the software engineering community through active participation in professional organizations
- Placement of press releases, announcements, and paid advertisements concerning DACS products and professional activities in professional journals, newspapers, and magazines circulated to the software engineering community
- Publication and dissemination of informational materials designed and developed by the DACS staff

Activities relating to the dissemination of information are discussed in this section; the promotional aspects of the current awareness program are discussed under Task 8, Promotional Advertising.

6.2 DACS NEWSLETTER

The newsletter is the primary means for the dissemination of current information to the DACS user community. Each issue contains synopses and critiques of significant, newly acquired reports or articles; summaries of new R&D programs; listings of future conferences and symposia; summaries of significant technological breakthroughs and new technological applications;

and highlights of other outstanding developments of interest to DACS users. The DACS Newsletter is also used as a vehicle to announce new DACS products and programs to its user community. One DACS product is featured in each issue, with capsule summaries of other products featured as space permits.

The DACS Newsletter is distributed free of charge to government and nongovernment personnel who are interested in the disciplines served by DACS. The DACS Newsletter is mailed to the more than 2,200 individuals and is also distributed at conferences attended by DACS personnel. Figure 6.2-1 shows the front page of the December 1985 issue of the DACS Newsletter.

6.3 DACS BULLETINS

The first DACS Bulletin was published in April 1979, and since then 50 issues have been published, 26 issues during this contract period. Figure 6.3-1 illustrates the front page of the January 1986 issue of the DACS Bulletin.

The bulletin has been regularly distributed on a limited basis to RADC/CO personnel and selected individuals. The DACS Bulletin usually treats a topic of high interest in greater depth than space allows in the newsletter. Certain issues of particular interest to our general user community have been publicized in the newsletter and were distributed on request for a nominal charge. Table 6.3-1 provides a list of the DACS Bulletins produced during this contract period.

6.4 TECHNICAL PRESENTATIONS

Fourteen technical presentations were made by DACS personnel during this reporting period. Technical presentations are an effective way to inform the technical community of the concerns and activities of the DACS and to attract new users. They also serve to identify areas of concern in the DACS user community, new sources of data for the data acquisition program, and inputs for the newsletters and bulletins. In addition to technical presentations at client sites and technical symposia, presentations were made at the DACS to

DACS NEWSLETTER

Data & Analysis Center for Software

RADC/COED
Griffiss AFB, NY 13441-5700
315/336-0937
Autovon 587-3336

Volume IV Number 4
December 1988

DACS @ RADC Multics

EDITOR'S NOTES

This edition of the newsletter is for the most part devoted to informing our readers about the availability of certain documents they may be interested in. A new feature includes a description of one of the tools included in the DACS Software Tool Information (STI) Database (See September '85 newsletter). Interest in such a feature was strongly expressed in our DACS Users Survey.

GLOSSARY OF SOFTWARE QUALITY TERMS

According to the IEEE Standard Glossary of Software Engineering Terminology, software quality is the totality of features and characteristics of a software product that bear on its ability to satisfy given needs. Considerable research has been conducted in the area of software quality measures and metrics. In spite of this research, no universally accepted set of measures for software quality yet exists. In fact, the quality factors and attributes that have been proposed in this research vary in both taxonomy and definition. The Data & Analysis Center for Software (DACS) has produced a draft "Glossary of Software Quality Terms" to provide a single reference for definitions of terminology related to software quality.

This glossary includes terms from some of the earliest work in this area to some of the most recent work. These terms are derived from efforts related to software quality sponsored by Rome Air Development Center (RADC), the National Bureau of Standards (NBS), and the Air Force Operational Test & Evaluation Center (AFOTEC). The glossary includes the definitions found in the draft military standard for software quality evaluation (DOD-STD-2168). Related terms from software engineering glossaries developed by the National Aeronautics and Space Administration Software Engineering Laboratory (NASA/SEL) and the Institute of Electrical and Electronics Engineers Computer Society (IEEE-CS) have also been included.

Copies of the glossary are available from the DACS. This glossary is presented as a draft to encourage others to contribute additional references. Any comments on sources, format, or scope are welcomed.

COMPSAC85

The IEEE Computer Society's Ninth International Computer Software & Applications Conference (COMPSAC85) was held from October 9 to 11, 1985 in Chicago. The proceedings are available from

IEEE Computer Society
Post Office Box 80452
Worldway Postal Center
Los Angeles, CA 90080

FIRST DOD/INDUSTRY STARS PROGRAM CONFERENCE

The first DOD/Industry STARS Program Conference was hosted by the National Security Industrial Association (NSIA) Software Committee from April 30 to May 2, 1985. Sessions were held in each of the six thrust areas: applications, business practices, human resources, measurement, methodology, and software engineering environments. See the June 1985 DACS Newsletter for more details about the conference. Proceedings for this conference are now available for $45 from

NSIA Headquarters
Suite 901
1015 15th Street, N W
Washington, DC 20005
202-393-362

Figure 6.2-1. The DACS Newsletter is Distributed to Personnel Interested in the Disciplines Served by the DACS

DACS BULLETIN

Volume VI Number 1
January, 1986

Data & Analysis Center for Software

RADC/COED
Griffiss AFB, NY 13441

315/336-0937
Autovon: 587-3395

NASA SEL'S TENTH ANNUAL SOFTWARE ENGINEERING WORKSHOP

The Software Engineering Laboratory (SEL) at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland hosted the Tenth Annual Software Engineering Workshop on December 4, 1985.

John Quann, Deputy Director of NASA/GSFC, welcomed the group with remarks on the growth of the workshop to its current size and predictions of continued growth in the future. Due to an increased focus on Ada* by the Workshop, a growing interest in Space Station software and its development environment, and an expanding international awareness of the need to stay current with Ada, Quann predicted a need for larger facilities and longer duration for the 1986 Workshop.

The Workshop was structured around four sessions, each with its own topic. Each session included an introducer and two to four presenters.

Jerry Page of Computer Sciences Corporation introduced the first session and gave an overview and history of the SEL. Since its establishment in 1976, experiments have been conducted on over 50 projects, ranging in size from 2,000 to 160,000 source lines of code. It was against this backdrop that papers on the first topic, Research in the SEL, were presented.

Victor Basili of the University of Maryland delivered the first talk of the opening session, "Measuring the Software Process and Product: Lessons Learned in the SEL." The rationale for measuring software and its development process were said to include the development of a corporate memory, the determination of strengths and weaknesses of current practices and procedures, the development of a rationale for adopting techniques, the assessment of the impact of techniques, and the evaluation of the quality of the procedure and the product.

A 5-step, goal-driven paradigm was presented for data collection: (1) establish goals, (2) develop specific questions and subgoals, (3) determine metrics, (4) design data collection forms, and (5) collect and analyze data.

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*Ada is a registered trademark of the Department of Defense (Ada Joint Program Office).

The Data & Analysis Center for Software is a DoD Information Analysis Center
sponsored by IIT Research Institute

Figure 6.3-1. The DACS Bulletin Focuses on a Single Topic

TABLE 6.3-1. TWENTY-SIX ISSUES OF THE DACS BULLETIN WERE PRODUCED BY DACS STAFF MEMBERS

ISSUE	TITLE	AUTHOR
January 1983	Notes on the 7th Annual NASA/Goddard Software Engineering Workshop	J. Romeu
February 1983	RAMS 1983 From a Combined Hardware Software System Perspective	J. Romeau
April 1983	Simulating Software Engineering Progress, A Report of the Software Engineering Group	S. Gloss-Soler
May 1983	New Books at the DACS	S. Gloss-Soler
July 1983	Report on The Second Software Engineering Standards Applications Workshop	S. Gloss-Soler
August 1983	Softfair	G. Brement
October 1983	Cost-Reliability Trade-Offs: A Talk by Dr. Barry Boehm	J. Romeau
November 1983	Software Cost Estimation	R. Iuorno
January 1984	Criteria for Software Reliability Model Comparisons: A Review	J. Romeu
February 1984	Software Reliability at RAMS 1984	J. Romeu
April 1984	The Ada" Information Clearinghouse	E. Swedo
May 1984	STARS Measurement DIDs Workshop	N. Sunderhaft
July 1984	The DACS Software Engineering Data Collection Package	N. Sunderhaft
August 1984	Fortran 8X	T Robbins
October 1984	AISE Software Portability Survey	T. Robbins
November 1984	The Hamilton College Seminar Series on Artificial Intelligence	N. Sunderhaft G. Brement
January 1985	The Fifth Generation Project After the First Three Years	N. Sunderhaft
February 1985	COMPSAC 1984 Presentation	E. Fedchak
April 1985	Ninth Annual Software Engineering Workshop	J. Romeu
May 1985	STARS Measurement Update	N. Sunderhaft
August 1985	Eighth Minnowbrook Workshop on Software Performance Evaluation	R. Vienneau
October 1985	Software Life Cycle Tools	G. Brement
November 1985	Glossary of Software Quality Terms	T Robbins
January 1986	NASA SEL's Tenth Annual Software Engineering Workshop	D Preston
February 1986	SEI Hosts Software Factory Forum	N. Sunderhaft
April 1986	NSIA and National Institute on Software Quality and Productivity Conferences	R. Vienneau

persons or groups visiting Griffiss Air Force Base for meetings and workshops. A sample of DACS presentations can be found in Table 6.4-1.

6.5 SUMMARY

This vigorous current awareness program has resulted in several benefits to the DACS.

- o DACS personnel have established a network of contacts throughout the software engineering community and are regularly invited to make presentations at conferences and symposia

- o DACS personnel have developed an in-depth knowledge of the needs and concerns of the DACS user community; this knowledge is needed to prepare and publish newsletters and bulletins which are both informative and useful

- o DACS personnel have developed production and quality control procedures to assure that newsletters and informational materials are of high quality in both appearance and technical content

- o Through participation in technical symposia, workshops, and professional activities, DACS personnel have acquired a broad base of information regarding the activities of individuals and organizations in the field of software engineering.

TABLE 6.4-1. TECHNICAL PRESENTATIONS MADE AS PART OF THE CURRENT AWARENESS PROGRAM

DATE	AUTHOR(S)	TITLE	PRESENTATION
January 1985	Lorraine Duvall	The Products and Services of the DACS	Motorola Scientific Advisory
February 1985	Lorraine Duvall Thomas Robbins	Software Technology	Electronic Systems Division Hanscomb AFB, MA February 7, 1985
November 1984	Clifford Carroll	An Approach to the Evaluation of Software for Embedded Computer Systems	COMPSAC Conference Chicago, IL November 6-9, 1984
	Elaine Fedchak	Software Standards and Electronic Process Control Systems in ARMY Armament Plants	
July 1984	Thomas Robbins	Status of the STARS Measurement DIDs Review	AdaTec Conference Hyannis, MA July 30 - August 1, 1984
March 1984	Jorge Romeu	A Simulation Approach for the Analysis and Forecast of Software Productivity	Computers and Industrial Engineering Conference Orlando, FL March 27, 1984

TABLE 6.4-1. TECHNICAL PRESENTATIONS MADE AS PART OF THE CURRENT AWARENESS PROGRAM (CONT'D)

DATE	AUTHOR(S)	TITLE	PRESENTATION
December 1983	Jorge Romeu	An Approach to Software Baseline Generation	Eighth Annual Software Workshop NASA Goddard Space Flight Ctr. Washington, DC December 1, 1983
November 1983	Lorraine Duvall	Programming Productivity	Productivity Conference Chicago, IL November 9, 1983
	Jorge Romeu	Measurement Problems in Software Engineering Data	IEEE COMPSAC Conference Chicago, IL November 8-12, 1983
July 1983	Lorraine Duvall	Software Engineering	Air Force Studies Board National Academy of Sciences Woods Hole, MA July 16-20, 1983
June 1983	Lorraine Duvall	Perspectives on Software Technology	NBS Workshop Washington, DC June 9-10, 1983
May 1983	Lorraine Duvall	Future Trends in Software Technology	AWC Conference Los Angeles, CA

TABLE 6.4-1. TECHNICAL PRESENTATIONS MADE AS PART OF THE CURRENT AWARENESS PROGRAM (CONT'D)

DATE	AUTHOR(S)	TITLE	PRESENTATION
May 1983	Shirley Gloss-Soler	Standards Development	Second Software Engineering Standards Applications San Francisco, CA May 21, 1983
April 1983	Jorge Romeu	Parametric vs Nonparametric Techniques in the Analysis of Software Engineering Data	American Statistical Assoc. Syracuse, NY April 8, 1983

7.0 TASK 6 - PRODUCTS AND SERVICES PREPARATION AND DISTRIBUTION

7.1 INTRODUCTION

This section summarizes the results of the tasks to produce and distribute the DACS products and services. A characterization of these products and services is presented, along with summarized quantitative information on requests processed.

7.2 DATA SERVICES

Computer readable and hard copy subsets of the data contained in the DACS SLED are produced and distributed in response to specific requests to aid in research efforts that require productivity, cost, complexity, error and change data. Typically, these datasets are used to validate and refine software reliability, maintainability, and estimation models and to aid in additional data analysis studies that require empirical data.

When a dataset is requested, the description of which data items and type, the sorted order, and other information must be known; if the description is not included in the request, DACS personnel contact the user directly. During the pilot period a history of requests was kept. As patterns of use developed, standard options were identified to ease the processing load on engineering personnel. Parameterized HOL procedures were written, allowing clerical personnel to produce data subsets for standard options. Additional options have been identified, and parameterized procedures for additional datasets were produced during this contract period. The DACS has distributed 125 copies of SLED datasets in hard copy report format or on magnetic tape.

To facilitate distribution of these datasets and their subsets, descriptive literature on SLED datasets is provided to the potential purchaser along with an order form. Upon receipt of the order, the tape or hardcopy listing is generated. The data is then sent along with a data dictionary describing the data elements.

7.2.1 Data Compendium

The DACS Data Compendium is a summarization of the data contained in the SLED. It contains descriptions of the datasets (described in Section 3.5 of this report), DACS products and services ordering information, and record formats for all the datasets described.

DACS personnel periodically updated information in the compendium to reflect any changes made to the descriptions of data contained in the SLED. The third and fourth editions of the compendium were produced during this contract period.

7.3 STATE-OF-THE-ART REVIEWS

An effective approach to stimulating user interest in the DACS is through the design, preparation and distribution of products that constitute the authoritative sources of information needed throughout the software engineering community. State-of-the-art reviews (SOARs) are intended to consolidate and synthesize information on a specific high-interest technology area from multiple sources into a single document containing all pertinent information in a condensed, easy-to-assimilate form. SOARs are most useful when the topic areas they cover have received a substantial amount of attention by scattered researchers (indicating a broad interest), but the research objectives and results have not been previously consolidated. In fast moving technologies, it may be appropriate to update a SOAR periodically.

Six such SOARs were produced during this contract period:

(1) The DACS Software Engineering Data Collection Package

(2) Software Life Cycle Tools Descriptions

(3) Software Engineering Standards Analysis: An Application to the Development of a High Quality System

(4) Application of Tools, Technologies and Methodologies for Rule-Based Expert Systems

(5) A Review of Software Engineering Environments

(6) Determination of Data Collection Needs for the Ada Program.

7.4 SOFTWARE ENGINEERING BIBLIOGRAPHY

Scientists and engineers depend upon well-designed bibliographies for ready access to previous work and published literature. To be most useful, entries must be comprehensively indexed with terms that are pertinent to and in common use within the community being served. In response to this need, the DACS developed the DACS Thesaurus, a standard word list used for indexing documents in the DACS library and has published and disseminated The DACS Annotated Bibliography. The DACS bibliography set currently consists of an intitial volume and four supplements, three of which were produced during this contract period. The total number of citations included in the set is 5,513. Bibliography volumes contain a section having a citation and abstract for each document, a copy of the thesaurus, an index of subjects, an index of authors, and a keyword-in-context listing of the document titles. Instructions for using the bibliography and document ordering information are also included. The set of published bibliographies is available to DACS users.

7.5 BIBLIOGRAPHIC SERVICES

Bibliographic inquiries to the DACS are received in many forms: by letter, telephone call, and visit, or by use of the bibliographic request form contained in The DACS Annotated Bibliography. The information requests have ranged from very specific to general questions on software engineering methodologies. The DACS has conducted 51 bibliographic searches during this contract period. DACS personnel have also provided consultation services on 109 requests for bibliographic assistance.

Bibliographic inquiries are processed on a timely basis, with a search strategy generated and an on-line search of the DACS database normally made within one or two days from receipt of an inquiry. Inquiries are tracked to ensure that response time does not exceed ten days; responses may take the form of a letter or listing. In those cases where the user needs immediate

response by telephone or telegraph, a copy of the telegram or a memorandum-for-record is filed. Abstracts are supplied with the custom bibliographies, which are reviewed by a member of the DACS technical staff to ensure that the material is pertinent to the subject. The DACS has developed efficient search procedures and has refined them to provide more focused bibliographies in response to specific user requests.

7.6 CUSTOM TOOL SEARCHES

During this contract reporting period, the DACS continued the custom search service for software tools. A custom search involves automated searches of the DACS STI Database.

The information provided on each software tool includes: tool title and/or acronym, classification, features/functions, stage/date of development, applicability, implementation language, portability, size hardware, restrictions, availability, an abstract or summary, documentation, contact, and developer. The DACS performed 50 custom tool searches during this reporting period.

7.7 TECHNICAL INQUIRIES

Technical inquiries to the DACS are received by mail, telephone call, or in person and are processed on a daily basis. Information requests range from general inquiries to very specific questions.

Technical inquiries are answered in different ways, depending on the nature of the inquiry and the complexity of the reply. Responses include:

- Custom bibliographic search on the subject area of interest
- Summary information supplied based on a preliminary analysis of the subject literature
- Production of a subset of a DACS database
- Distribution of relevant DACS literature
- Referral to other sources of information

Figure 7.7-1 shows the types of inquiries received by the DACS during each month of this contract period.

Certain inquiries of a very specific technical nature may not be answerable in terms of a dataset, a bibliographic search, or a published DACS product, but may be answered relatively quickly by a DACS specialist. For such inquiries, DACS provides engineering services in the form of technical guidance, with additional DACS products included, as appropriate. A total of 2,452 technical inquiries were processed during this contract period. The DACS responds to technical inquiries within ten working days.

7.8 TECHNOLOGY ASSESSMENTS

Technology assessments are special studies that generally exceed the scope of a technical inquiry response, but are usually shorter than a state-of-the-art review. They are directed toward evaluating and synthesizing the latest available information resulting from recent research and development findings or are comparative assessments based on technical characteristics. For example, a technology assessment may involve the extraction and compilation of specialized data from several independent works to evaluate their differences; it may be a synopsis of pertinent findings from available documentation; or it may compare different approaches to a life cycle process, using documented specifications and results.

The titles of the six technology assessments produced during this contract period are:

(1) A Compendium of Software Engineering Standards

(2) A Simulation Approach for the Analysis and Forecast of Software Productivity

(3) An Approach to the Evaluation of Software for Embedded Systems

(4) Programming Languages for Artificial Intelligence Systems

(5) An Overview of DOD-STD-2167

(6) Calibration of the COCOMO Cost Calibration Model.

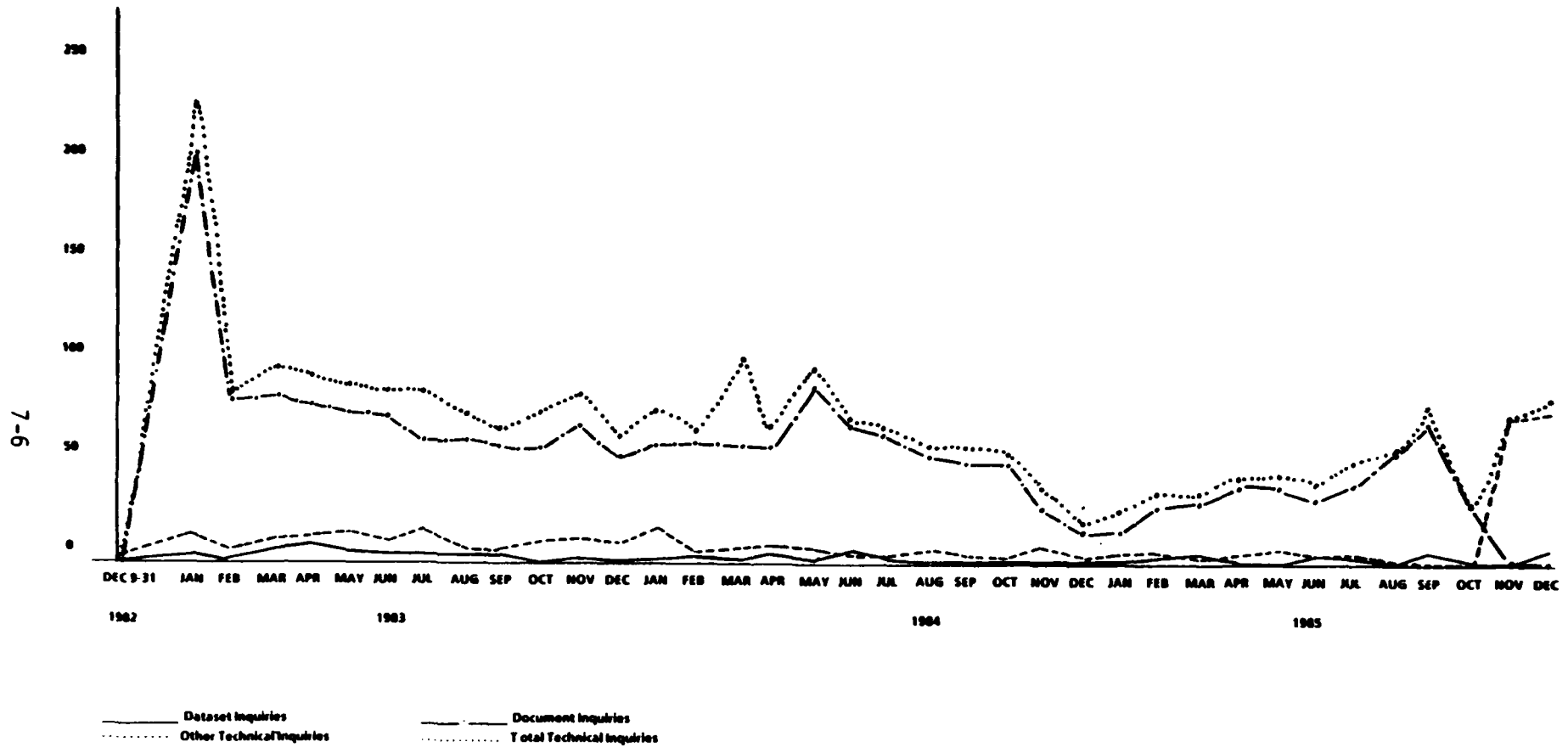


Figure 7.7-1. DACS Inquiries/Month from December 1982 to December 1985

8.0 TASK 7 - PREPARING, DISTRIBUTING, REVIEWING AND IMPROVING PRODUCTS AND SERVICES

8.1 PREPARING AND DISTRIBUTING PRODUCTS AND SERVICES

A vital component of a responsive information analysis center is its ability to provide products that reflect the needs of its users. The following new products and services were introduced to DACS users during this contract period:

- JLC Software Development Specifications - Versions II, III - a draft of four standards and supporting Data Item Descriptions aimed at providing a disciplined software development process for DOD software acquisition
- DACS Data Compendium - a description of software experience data available from the DACS; includes types of data, number of records of each type, and record formats
- KERNAL Ada Program Support Environment (KAPSE) Interface Team Public Report - Version II, III - a report published by the KAPSE Interface team (KIT), whose objectives are to evaluate and establish KAPSE standards
- Software Technology for Adaptable, Reliable Systems (STARS) - revised plan for the STARS program; ten reports packaged as one volume
- DIANA Reference Manual - introduction and reference manual for a Descriptive Intermediate Attributed Notation for Ada (DIANA)
- Ada Bibliography - citations and abstracts for over 350 documents pertaining to the history, development, progress, and uses of the Ada language
- Catalog of Resources for Education in Ada and Software Engineering (CREASE) - Vol. I, II - catalog of courses, seminars, and training programs on Ada and software engineering
- Draft Specification of the Common APSE Interface Set (CAIS) - specification for a set of Ada packages which together form a CAIS for Ada Programming Support Environments (APSEs)
- DACS Software Engineering Data Collection Package - produced by the DACS to help organize the data items necessary to support analysis activities into a classification scheme and to promote standardized collection of software engineering data

- DACS Annotated Bibliography - Vol. III, IV - a collection of citations and abstracts of literature on software engineering and software technology

- Software Development Standards (SDS) Documentation Set - a set of four standards and the supporting data item descriptions

- The Software Engineering Life Cycle Tools Directory - a directory of over 400 software tools contained in the Software Tool Information (STI) database maintained by the DACS

8.2 IMPROVEMENT OF DACS PRODUCTS AND SERVICES

The products and services of the DACS are continually reviewed and assessed with the objective of enhancing both the DACS and its products and services. Concerns of the enhancement efforts extend to all facets of the DACS operations, including improving the technical quality of DACS products, increasing the scope of data coverage, improving analysis routines, improving data handling capability, operating more efficiently, and increasing services to the user community. During this contract period significant improvements have been made in several areas. These improvements include the following:

- Increasing the scope of data coverage by the acquisition of:
  - NASA-Ames Data
  - AIRMICS Data
  - Jet Propulsion Laboratory Data
- Improving analysis routines
- Improving software pertaining to DACS STINFO Databases
- Increasing efficiency in record-keeping achieved by the maintenance of the on-line User Profile Database
- Streamlining the process for entry of bibliographic information into the bibliographic database
- Reviewing technical content of final drafts by IITRI personnel who have expertise in software technology but who are not members of the DACS core group
- Reviewing of the final draft of all planned publications by a technical editor, with respect to style, clarity of writing, correctness of grammar and spelling

8.3 CONTINUING ASSESSMENT OF USER NEEDS

The DACS has used two methods to determine the needs of its users: (1) surveys to identify user requirements, and (2) historical records of user requests. These two activities have been pursued to ensure that DACS products and services meet the needs of the user community.

User surveys conducted by the DACS have included questions which characterize user organizations, job descriptions, and areas of concern or interest in the field of software engineering. Free response questions elicit suggestions for new products and services. Figure 8.3-1 illustrates the distribution by organization and occupation of DACS users who responded to a June 1984 survey.

The most recent user survey was conducted in December 1985, and responses to this survey are still being collected and analyzed. An earlier survey conducted in June 1984 elicited over 600 responses from the 2,000 questionnaires distributed, a very high level of response for this type of survey. Figure 8.3-2 shows the forms used for the two surveys. User responses were carefully reviewed and tabulated to determine areas of interest and concern. Areas of interest identified by the June 1984 User Survey are shown in Fig. 8.3-3. In general, this survey showed that industry is seeking technology, tools, and information with which to solve the very problem the DACS was created to address: how to produce high-quality, reliable software at a reasonable cost.

Figure 8.3-4 illustrates the Service Request Record, which is used to track and record services performed by the DACS in terms of the user (requestor), the type of service provided, and the resources expended. This information is transferred to the User Profile Database (UPD) to accumulate the types of services provided to each user. Periodic tabulations of total user interactions with the DACS are generated from the database and are correlated with the results of user surveys to evaluate DACS responsiveness to user needs.

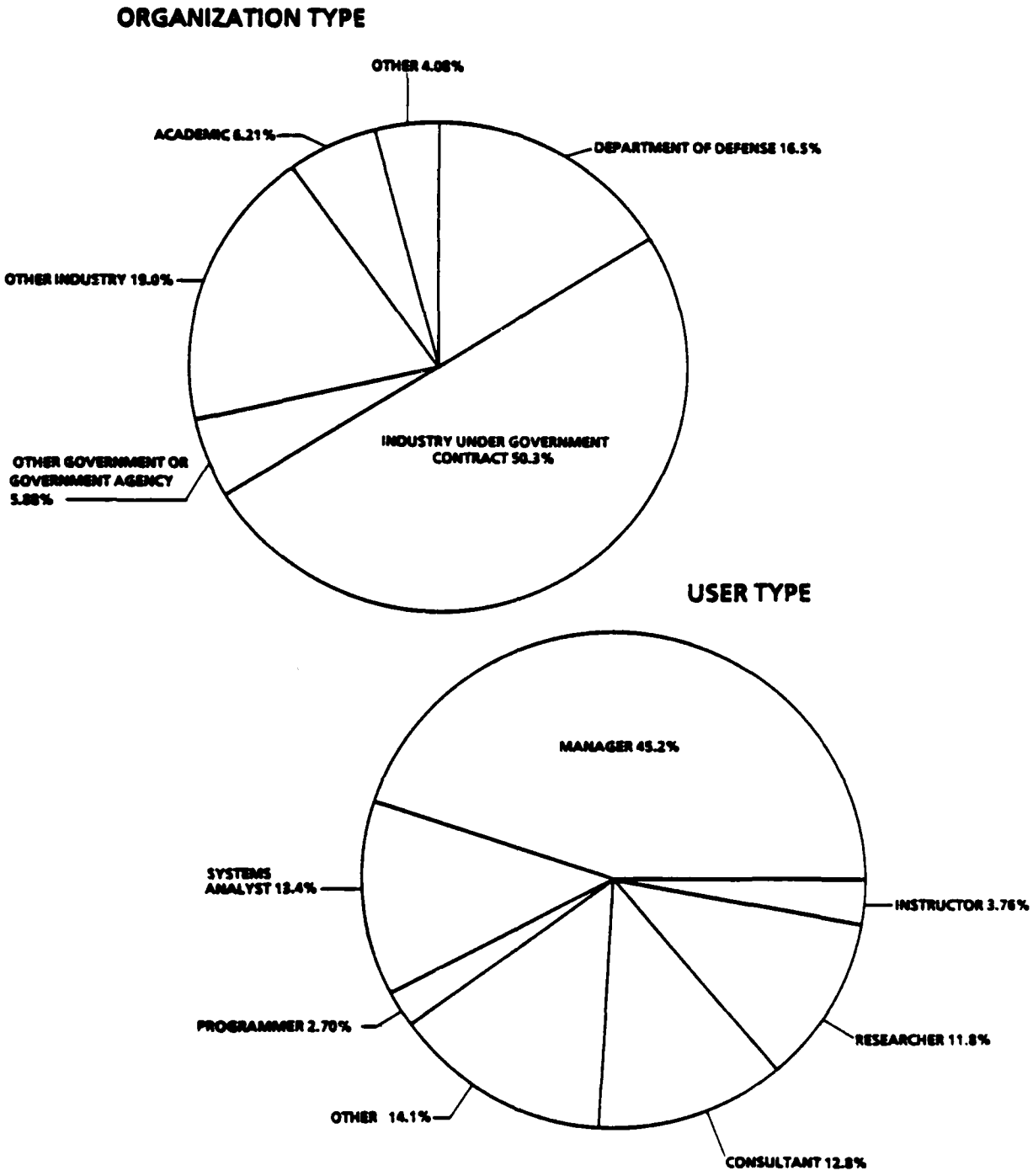
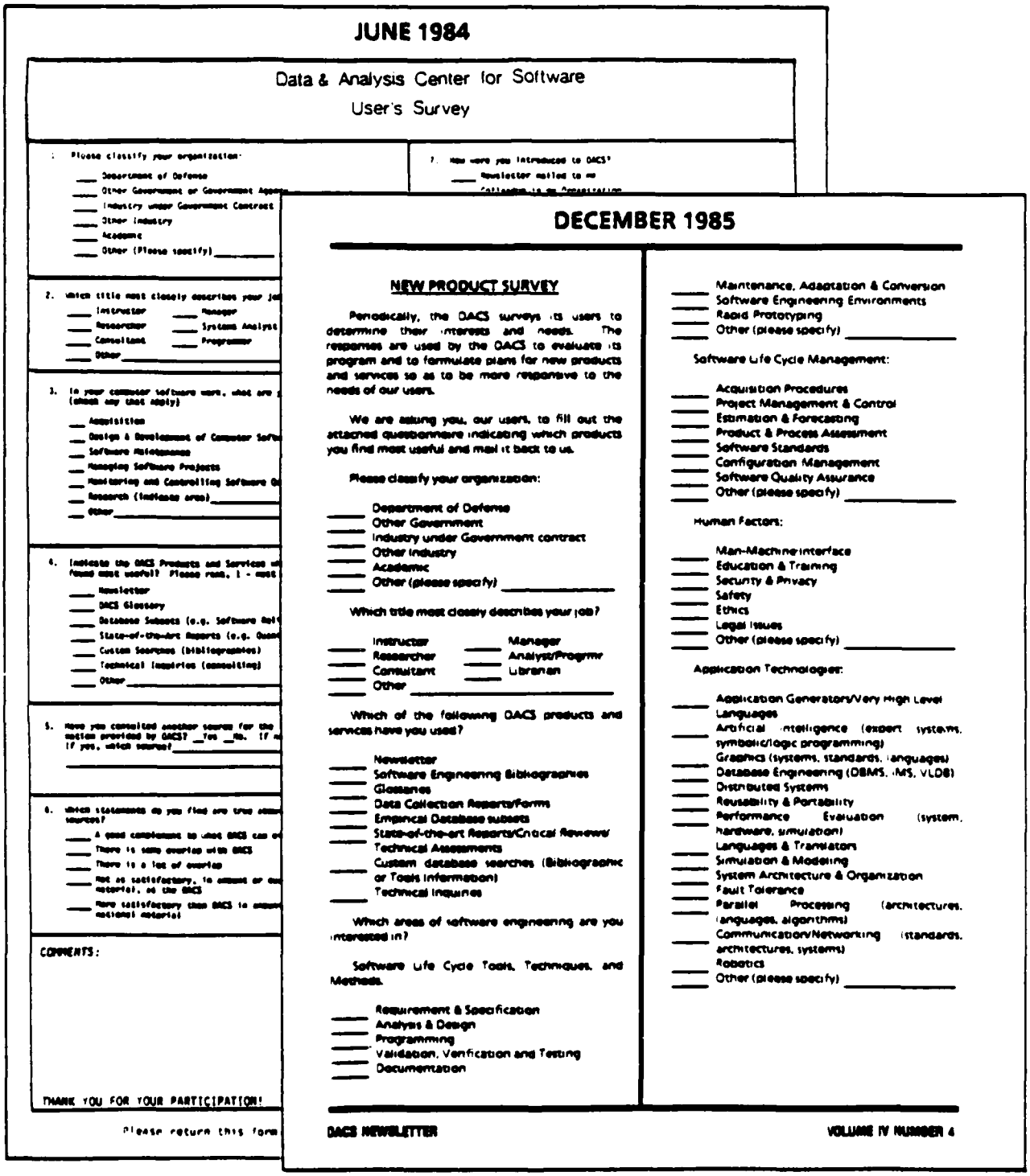


Figure 8.3-1. The June 1984 User Survey Revealed that Many Types of Organizations and Users are Served by the DACS



JUNE 1984

Data & Analysis Center for Software

User's Survey

DECEMBER 1985

NEW PRODUCT SURVEY

Periodically, the DACS surveys its users to determine their interests and needs. The responses are used by the DACS to evaluate its program and to formulate plans for new products and services so as to be more responsive to the needs of our users.

We are asking you, our users, to fill out the attached questionnaire indicating which products you find most useful and mail it back to us.

Please classify your organization:

____ Department of Defense
____ Other Government
____ Industry under Government contract
____ Other Industry
____ Academic
____ Other (please specify) _____

Which title most closely describes your job?

____ Instructor
____ Researcher
____ Consultant
____ Other _____
____ Manager
____ Analyst/Programmer
____ Librarian

Which of the following DACS products and services have you used?

____ Newsletter
____ Software Engineering Bibliographies
____ Glossaries
____ Data Collection Reports/Forms
____ Empirical Database subsets
____ State-of-the-art Reports/Critical Reviews/ Technical Assessments
____ Custom database searches (Bibliographic or Topic Information)
____ Technical Inquiries

Which areas of software engineering are you interested in?

Software Life Cycle Tools, Techniques, and Methods:

____ Requirement & Specification
____ Analysis & Design
____ Programming
____ Validation, Verification and Testing
____ Documentation
____ Maintenance, Adaptation & Conversion
____ Software Engineering Environments
____ Rapid Prototyping
____ Other (please specify) _____

Software Life Cycle Management:

____ Acquisition Procedures
____ Project Management & Control
____ Estimation & Forecasting
____ Product & Process Assessment
____ Software Standards
____ Configuration Management
____ Software Quality Assurance
____ Other (please specify) _____

Human Factors:

____ Man-Machine Interface
____ Education & Training
____ Security & Privacy
____ Safety
____ Ethics
____ Legal Issues
____ Other (please specify) _____

Application Technologies:

____ Application Generators/Very High Level Languages
____ Artificial Intelligence (expert systems, symbolic/logic programming)
____ Graphics (systems, standards, languages)
____ Database Engineering (DBMS, IMS, VLDB)
____ Distributed Systems
____ Reusability & Portability
____ Performance Evaluation (system, hardware, simulation)
____ Languages & Translators
____ Simulation & Modeling
____ System Architecture & Organization
____ Fault Tolerance
____ Parallel Processing (architectures, languages, algorithms)
____ Communication/Networking (standards, architectures, systems)
____ Robotics
____ Other (please specify) _____

COMMENTS:

THANK YOU FOR YOUR PARTICIPATION!

DACS NEWSLETTER VOLUME IV NUMBER 4

Figure 8.3-2. Two User Surveys (June 1984 and December 1985) Were Used to Identify the Software Engineering Areas of Greatest Interest to DACS Customers and to Develop New Products and Services

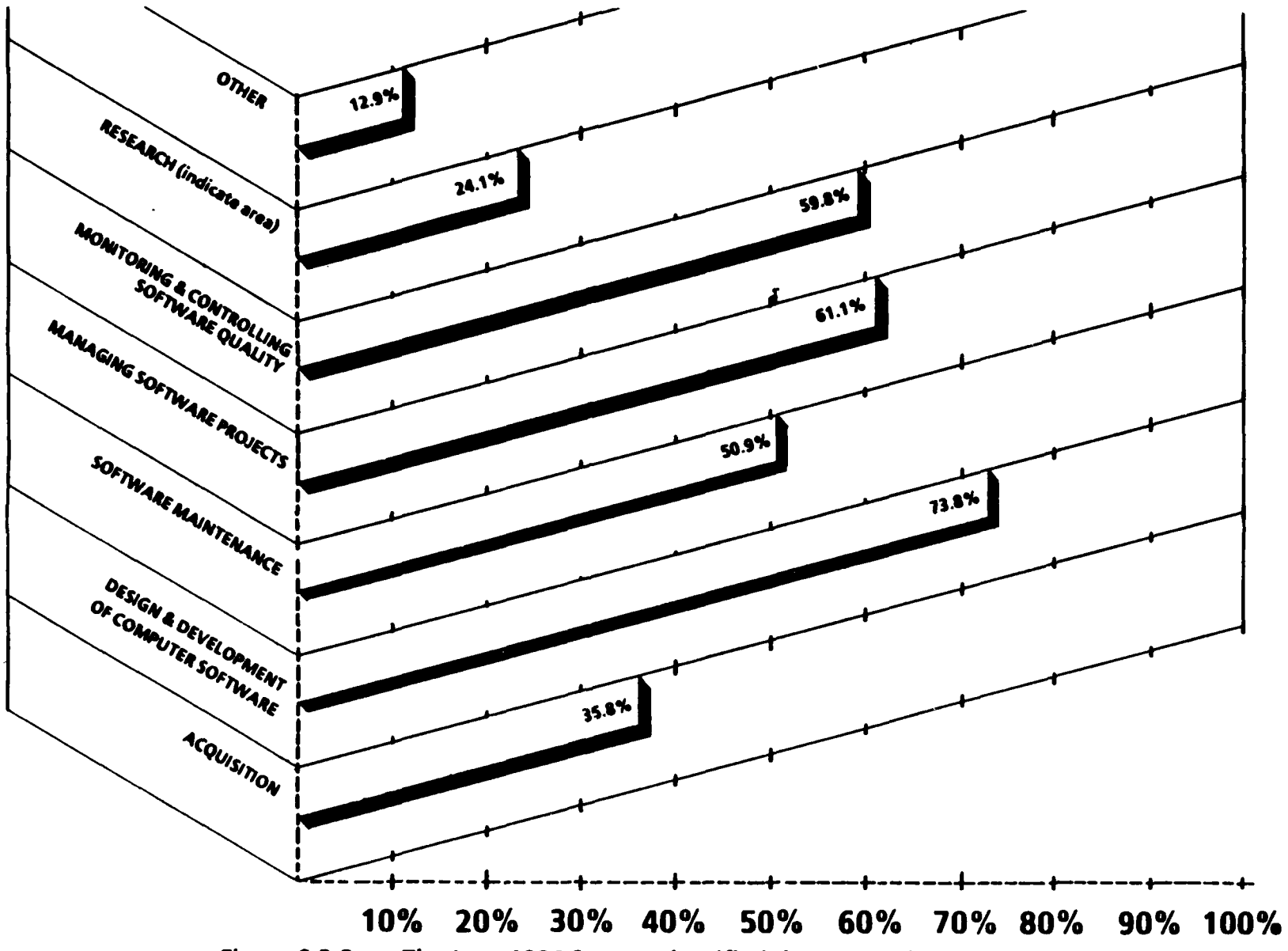


Figure 8.3-3. The June 1984 Survey Identified the Areas of High Interest to DACS Users

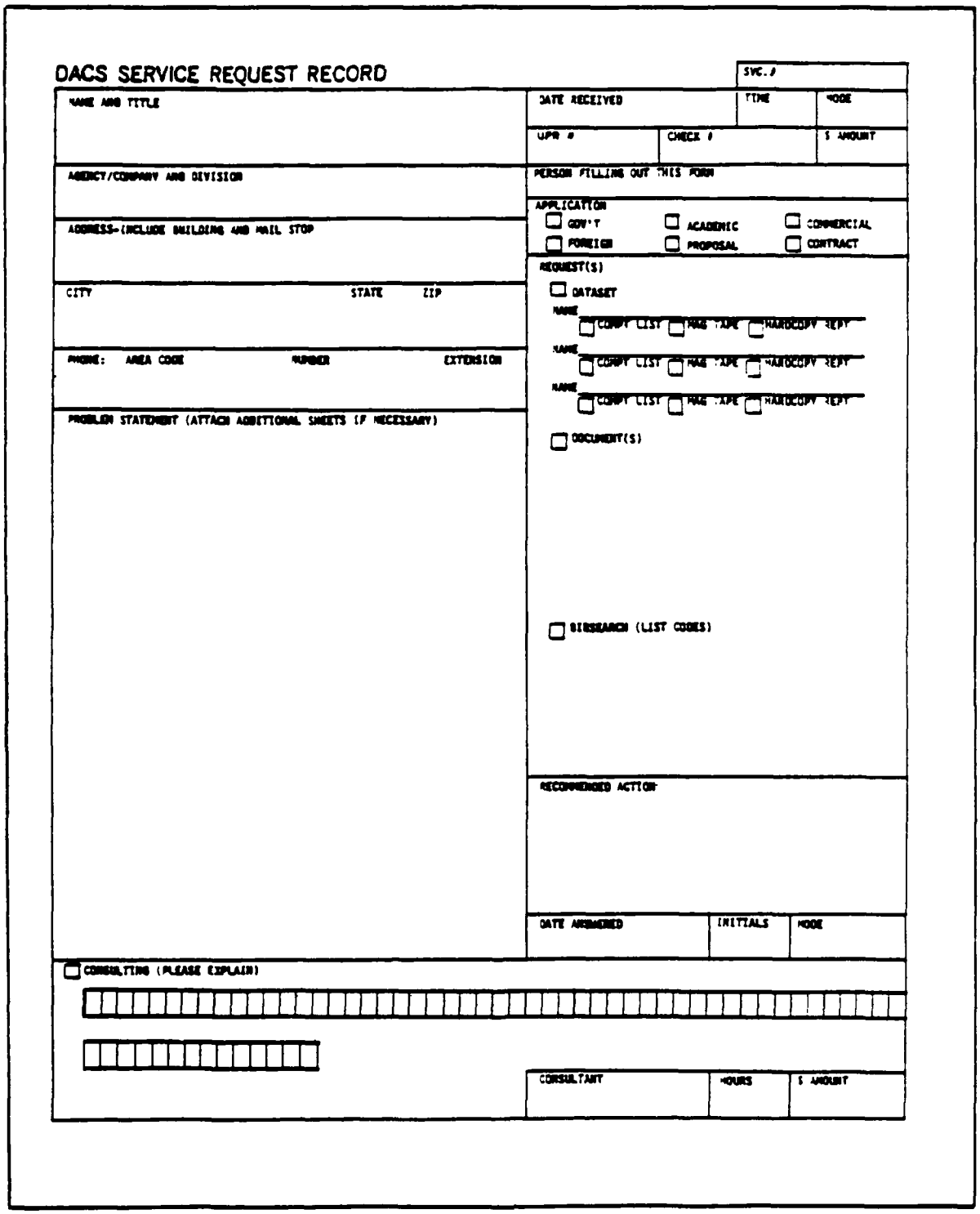


Figure 8.3-4. The Service Request Record Captures the History of a Completed User Request for DACS Products and Services

9.0 TASK 8 - PROMOTIONAL ADVERTISING

9.1 PROMOTION TO NEW USERS

Since it is unlikely that all potential users of the DACS have been identified or are on the mailing list for its newsletter, ongoing efforts are necessary to reach potential users. Potential users are defined as organizations or individuals known to participate in research and development or to use materials within the scope of the DACS, who have a high potential for benefit from the use of DACS products and services.

Promotion to persons and organizations in the potential user category was accomplished using the following techniques:

- Placement of press releases and announcements in journals, magazines and newspapers
- Presentations at conferences and symposia
- Procurement of mailing lists to which brochures, catalogs or other promotional materials could be sent

9.1.1 Promotion by Use of Free Publicity

There are several newspapers and magazines circulated free to software engineers that will print press releases and new product information at no charge to the DACS. In addition to sending announcements, fliers and brochures to several of these journals, editors of other journals and magazines requested information from the DACS on its products and services.

Specific instances of free publicity include:

- The March 1984 and June 1984 Language Control Facility Ada-Jovial Newsletter announced several new DACS products
- The DACS Newsletter received free publicity in the January 1984 issue of Software Maintenance News (published by the DPMA Special Interest Group on Software Maintenance)
- The June 1983 issue of the Communications of the ACM announced Software Technology for Adaptable, Reliable Systems (STARS) documents soon to be available from the DACS

- Custom searches on the DACS Software Tool Information (STI) database were referred to in the May 1983 issue of Computer

In addition to the free publicity mentioned above, the DACS produced and distributed free promotional fliers with information packets to reach potential users. Figures 9.1-1 and 9.1-2 show the promotional fliers and brochures that were produced during this contract period. The DACS Newsletter continued to be used as a regular promotional device. Each newsletter contains book reviews, state-of-the-art surveys, conference announcements along with featured DACS products (an article used to introduce new DACS products), and capsule summaries of selected products and services. The graph in Figure 9.1-3 shows user receipts by month. There is a noticeable increase in receipts when quarterly newsletters or brochures are distributed, indicating that these distributions are effective means of promoting DACS products and services.

9.1.2 Presentations at Conferences and Symposia

This topic is more fully discussed under Task 5, Current Awareness. It is only to be noted here that these presentations provided an excellent opportunity for one-on-one discussions, as well as personal communication with groups of potential users concerning the DACS and its products and services. The success of this promotional method indicates that it is worthwhile to continue to use presentations at conferences and symposia as a vehicle for promoting the DACS.

DACS

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Data & Analysis Center for Software

Products & Services Information March 1986

THE DACS IS...

A Department of Defense (DOD) Information Analysis Center sponsored by the Air Force Systems Command, Rome Air Development Center (RADC), and operated by IIT Research Institute (IITRI). The DACS was established to serve as a centralized source for current, readily available data and information concerning software technology.

Typical products provided by the DACS include subsets of the Software Life Cycle Empirical Database (SLED), data compendiums, analysis reports, bibliographies, newsletters, and technical monographs. DACS services include accumulating, maintaining, and tailoring data subsets for software technology research; bibliographic searches that provide rapid access to documents, reports, and papers concerning software engineering and software technology; and special technical studies which include technology assessments, critical reviews, and state-of-the-art surveys. Capsule summaries of currently available products follow.

CURRENT AWARENESS PUBLICATIONS

DACS NEWSLETTER. The DACS Newsletter is a quarterly publication that is intended to provide its readers with a general awareness of significant developments, trends, and technical activities in the software field. The DACS Newsletter is distributed free-of-charge and may be obtained by calling or writing the DACS.

DACS BULLETIN. This publication is produced eight times a year. The DACS Bulletin usually addresses a topic of high interest in greater depth than space allows in the Newsletter. Subscription is $20 per year. Copies are distributed free to members of DACS Participation Plans.

CUSTOM SEARCHES

CUSTOM BIBLIOGRAPHIC SEARCH. Automated search of the Software Engineering Bibliographic Database and abstracts of documents in the DACS library. Search includes books, reports, theses, journal articles relating to software engineering and DACS BIBGUIDE entries. $50; one or more specific topics.

CUSTOM SEARCHES. ...ing productivity data, error ...ification technologies. Magnetic tape. ...: Partial Report), $10.

...data on 16 software ...uring the phases of software test and operation. Hard-copy ... $10; Magnetic tape, $50.

...ODUCTIVITY DATASET. Common ele... of the DACS, NASA, and V&V datasets have been combined into one dataset using a ...ized record format. This combined dataset contains those parameters which have been identified as most common across the three datasets. Hard-copy listing $30; Magnetic tape $50.

ARF ERROR DATASET. Data describes 117 error reports, software characteristics data on 253 modules, and project aggregates for the Architecture Research Facility (ARF) developed at the Naval Research Laboratories. Hard-copy listing $10; Magnetic tape $50.

NASA/SEL DATASET. Data collected by the Software Engineering Laboratory (SEL), at NASA Goddard Space Flight Center, to measure the effectiveness of software development methodologies. The dataset contains over 45,000 records; the majority is from component status reports, and run analysis reports. The remainder of the dataset is project comment information, change reports, resource summary reports and component summary reports. Hard- copy listings $350; Magnetic tape, $150.

NASA/AMES DATASET. Error/fault data on 3,700 software problem reports collected on nine projects. Data was originally compiled by NASA Ames Research Center. Hard-copy listing $30; Magnetic tape $50.

NASA/SEL DATA COMPENDIUM. Specific information on 29 projects in the NASA/SEL database with potential applications for the data. Contains 126 pages of text, charts, graphs, and forms. $10 shipped UPS; $15 shipped first class mail.

NASA/SEL DATA COLLECTION FORMS. Forms used by the NASA Software Engineering Laboratory to collect life cycle data described above. No charge.

DACS PRODUCTIVITY DATA COLLECTION FORMS. Forms designed to collect software life cycle productivity-related data. No Charge.

DACS CONVERSION DATA COLLECTION FORMS. Forms and guidelines for collecting data on software conversion projects. No charge.

STARS INTERIM SOFTWARE ENGINEERING DATA COLLECTION FORMS SET. A set of eight documents, Executive Overview and Final Report on the Interim Software Data Collection Forms Development and six Interim Software Data Collection Forms covering Resource Expenditure, Software Characteristics, Software Test Information, Software Problem/Change, Software Environment, and Software Evaluation. $30 shipped UPS; $35 shipped first class mail.

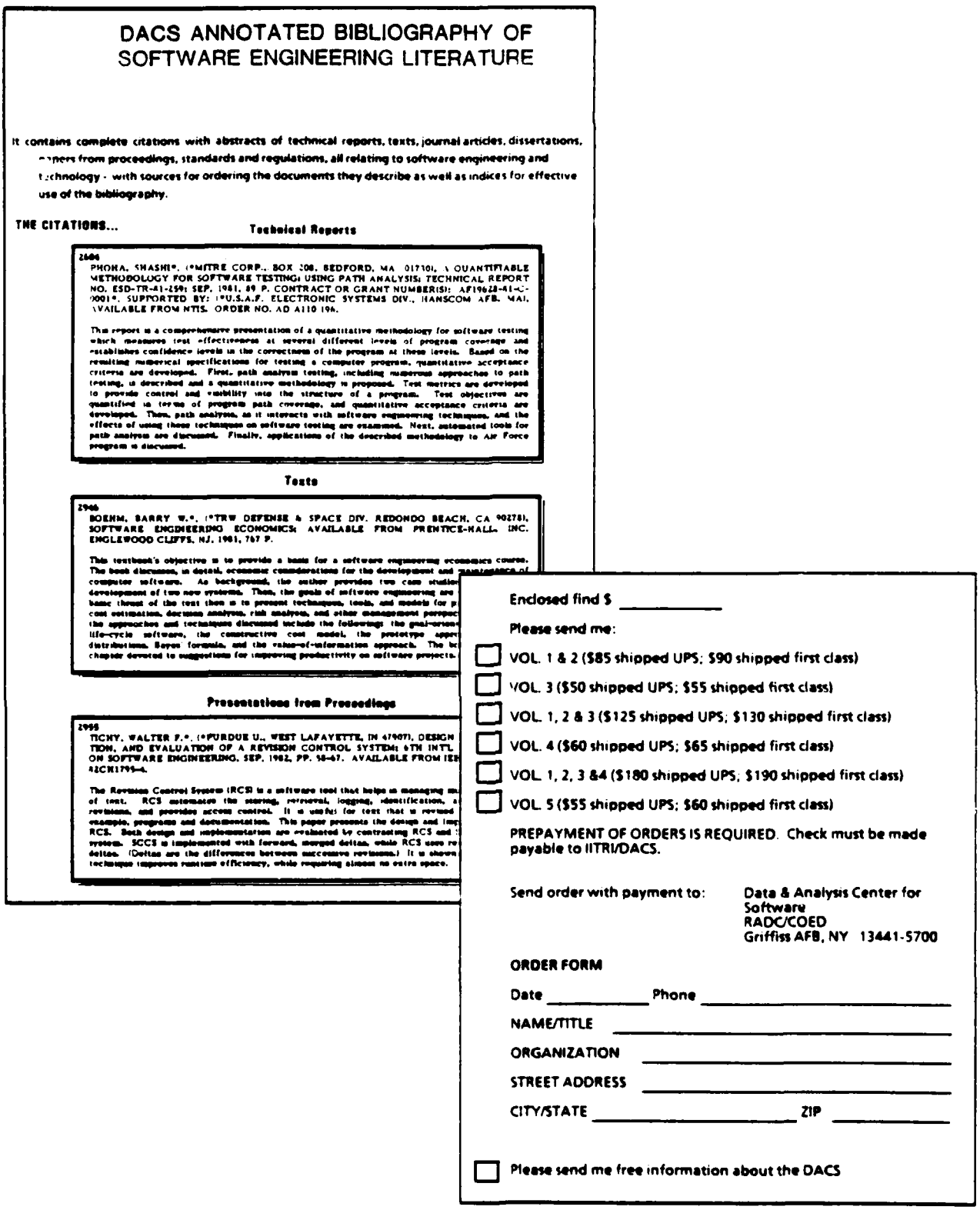
DACS SOFTWARE ENGINEERING DATA COLLECTION PACKAGE. Produced by the DACS as part of an effort to organize the data items necessary to support analysis activities into a classification scheme and to promote standardized collection of software engineering data. Section 1 of the package provides an overview of the data collection process, provides a classification scheme for the different types of data which may be collected, and introduces examples for applying the package to specific types of analyses. Section 2 presents the data collection forms and instructions for completing the forms. Section 3 contains a glossary of terms and data items contained in the report. Section 4 contains a list of references, and Section 5 contains an evaluation questionnaire. The questionnaire is included to encourage users' comments in refining the package. Individuals providing the DACS with technical input, returning a completed questionnaire, or providing data collected with the forms contained in the package will receive a complementary copy of the next version of the report. $10 shipped UPS; $15 shipped first class mail.

DOCUMENTS

DACS INFORMATION PACKET. A packet of information describing the products and services offered by the DACS. The packet includes sample DACS Newsletters, a guide to the Annotated Bibliography of Software Engineering Literature, and a flier on the DACS Software Tool Information (STI) Database. No charge.

The Data & Analysis Center for Software is a DoD Information Analysis Center operated by IIT Research Institute

Figure 9.1-1. Products and Services Brochure



DACS ANNOTATED BIBLIOGRAPHY OF SOFTWARE ENGINEERING LITERATURE

It contains complete citations with abstracts of technical reports, texts, journal articles, dissertations, papers from proceedings, standards and regulations, all relating to software engineering and technology - with sources for ordering the documents they describe as well as indices for effective use of the bibliography.

THE CITATIONS...

Technical Reports

2604
PHOHA, SHASHI*. (*MITRE CORP., BOX 208, BEDFORD, MA 01730). A QUANTIFIABLE METHODOLOGY FOR SOFTWARE TESTING: USING PATH ANALYSIS; TECHNICAL REPORT NO. ESD-TR-81-259; SEP. 1981, 89 P. CONTRACT OR GRANT NUMBER(S): AF19628-81-C-0001*. SUPPORTED BY: (*U.S.A.F. ELECTRONIC SYSTEMS DIV., HANSCOM AFB, MA). AVAILABLE FROM NTIS. ORDER NO. AD A110 196.

This report is a comprehensive presentation of a quantitative methodology for software testing which measures test effectiveness at several different levels of program coverage and establishes confidence levels in the correctness of the program at these levels. Based on the resulting numerical specifications for testing a computer program, quantitative acceptance criteria are developed. First, path analysis testing, including numerous approaches to path testing, is described and a quantitative methodology is proposed. Test metrics are developed to provide control and visibility into the structure of a program. Test objectives are quantified in terms of program path coverage, and quantitative acceptance criteria are developed. Then, path analysis, as it interacts with software engineering techniques, and the effects of using these techniques on software testing are examined. Next, automated tools for path analysis are discussed. Finally, applications of the described methodology to Air Force programs is discussed.

Texts

2946
BOEHM, BARRY W.*, (*TRW DEFENSE & SPACE DIV. REDONDO BEACH, CA 90278). SOFTWARE ENGINEERING ECONOMICS; AVAILABLE FROM PRENTICE-HALL, INC. ENGLEWOOD CLIFFS, NJ, 1981, 767 P.

This textbook's objective is to provide a basis for a software engineering economics course. The book discusses, in detail, economic considerations for the development and maintenance of computer software. As background, the author provides two case studies [illegible] development of two new systems. Then, the goals of software engineering are [illegible] basic thrust of the text then is to present techniques, tools, and models for [illegible] cost estimation, decision analysis, risk analysis, and other management perspec[illegible] the approaches and techniques discussed include the following: the goal-orient[illegible] life-cycle software, the constructive cost model, the prototype appro[illegible] distributions, Bayes formula, and the value-of-information approach. The la[illegible] chapter devoted to suggestions for improving productivity on software projects.

Presentations from Proceedings

2998
TICHY, WALTER F.*, (*PURDUE U., WEST LAFAYETTE, IN 47907). DESIGN [illegible] TION, AND EVALUATION OF A REVISION CONTROL SYSTEM; 6TH INT'L [illegible] ON SOFTWARE ENGINEERING, SEP. 1982, PP. 58-67. AVAILABLE FROM IEE[illegible] 82CH1795-4.

The Revision Control System (RCS) is a software tool that helps in managing m[illegible] of text. RCS automates the storing, retrieval, logging, identification, a[illegible] revisions, and provides access control. It is useful for text that is revised [illegible] examples, programs and documentation. This paper presents the design and imp[illegible] RCS. Both design and implementation are evaluated by contrasting RCS and [illegible] systems. SCCS is implemented with forward, merged deltas, while RCS uses re[illegible] deltas. (Deltas are the differences between successive revisions.) It is shown [illegible] technique improves runtime efficiency, while requiring almost no extra space.

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- ☐ VOL. 5 ($55 shipped UPS; $60 shipped first class)

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Figure 9.1-2. DACS Personnel Developed Fliers and Announcements to Promote New DACS Products

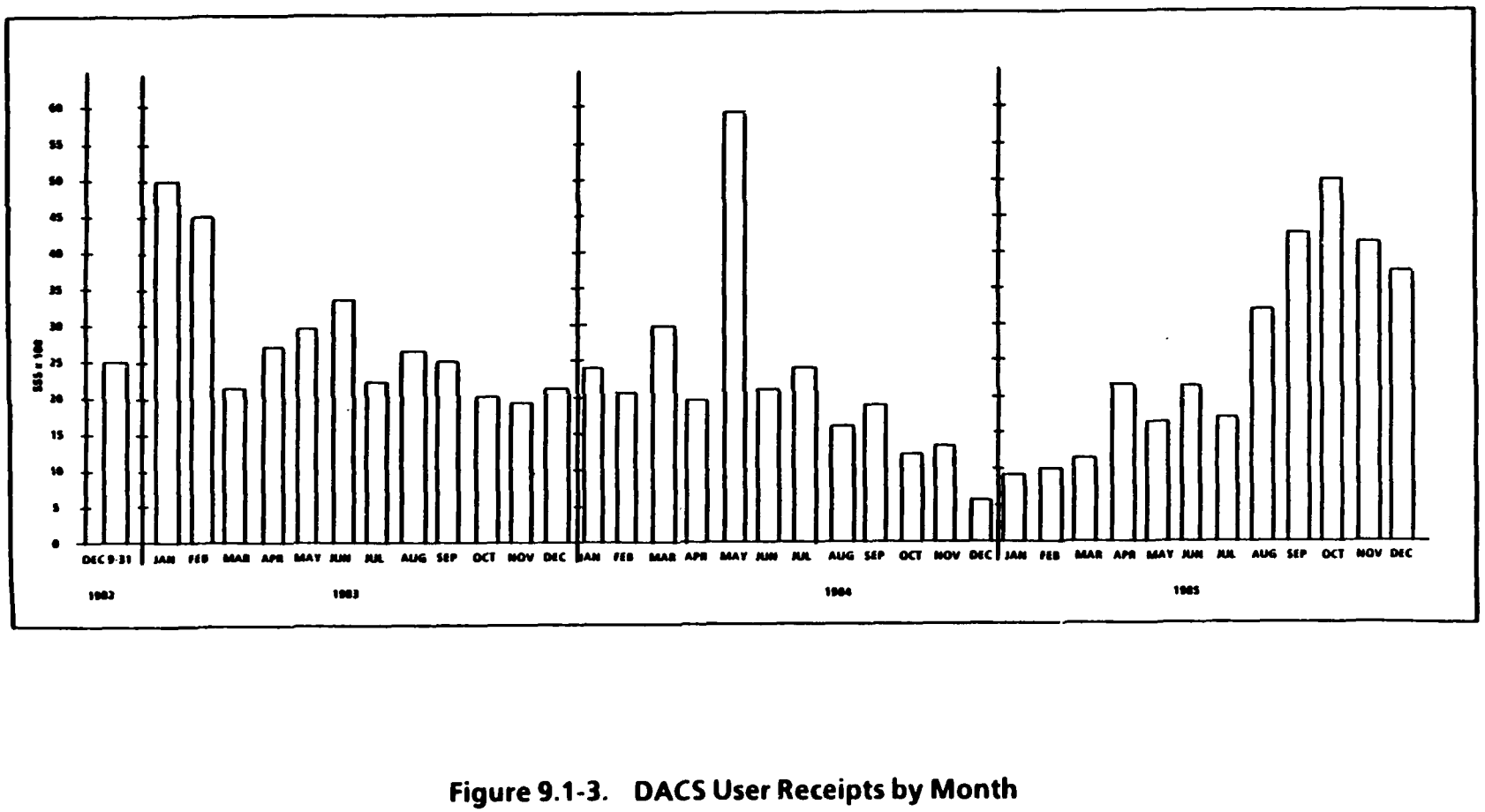

Figure 9.1-3. DACS User Receipts by Month

10.0 TASK 9 - SPECIAL STUDIES AND PROJECTS

There are many problems related to software technology that can be solved through the full service capabilities provided by the DACS. Many problems are sizable, requiring a substantial expenditure of engineering resources to accomplish. The DACS can make a significant contribution to increasing the productivity of software engineers and researchers and at the same time can make efficient use of accumulated information and resources.

The DACS can best serve its user community by identifying those areas in government and industry for which there is a need for the technological expertise and other resources of DACS, and by performing special studies tailored to the individual needs of particular organizations. Fourteen special studies were initiated during this contract period and are discussed in this section.

10.1 ESTABLISH A MEASUREMENT FRAMEWORK FOR THE STARS PROJECT

This DACS effort was conducted under contract to the Rome Air Development Center (RADC) for the DOD STARS Joint Program Office (SJPO). The SJPO tasked the DACS to support the STARS Software Measurement Task by developing a coherent and complete methodology which includes the collection, storage, maintenance and dissemination of software data. Specific objectives of this project were to develop a set of Data Item Descriptions (DIDs) for the collection of software engineering data on DOD software acquisition and support programs, and to establish a data collection coordination function for the STARS Measurement Project, within the present structure of the DACS.

After successfully meeting these objectives, the DACS continued to support the STARS Software Measurement Task. Results of these support efforts included the "STARS Measurement Survey Summary," which presents the results of a survey conducted by the DACS to determine the state of practice of software measurement in the defense software development community; the "Software Measurement Repository," a report providing a high-level overview for the establishment of a central database of software data; and the "STARS

Measurement Annotated Bibliography," a hard copy bibliography containing citations and abstracts for measurement-related literature.

10.2 SOFTWARE QUALITY ANALYSIS

The Software Quality Analysis Project was performed for the U.S. Army Development and Readiness Command (DARCOM). Under Phase I of this project the DACS performed a metric measurement of DARCOM's Long Range Budget Planning (LRBP) tool to assess the software quality of the tool. Enhancements and modifications were made to upgrade the LRBP tool as a result of the metrics measurement, and software data was collected during the update process.

Phase II involved installing the updated software tool at the designated sites, training personnel in its use, and collecting data in the operations and maintenance (O&M) environment. Much time and effort was saved by automating a previously tedious, error-prone, and time-consuming procedure.

During Phase III of this effort metrics data on maintainability and flexibility, and on additional O&M data was collected on a module-by-module basis on the tool resulting from Phase II. All data collected during phase III was included in the DACS SLED to facilitate further evaluation and future analysis.

10.3 DETERMINATION OF DATA COLLECTION NEEDS FOR THE ADA ENVIRONMENT

This special study was completed under contract to the Rome Air Development Center for the Ada Joint Program Office (AJPO). The AJPO required a set of data collection procedures to be used for collecting data on projects using the Ada language. A methodology was developed for collecting data in a consistent manner, allowing the collected data to support data analyses that would produce software development assessments for the Ada language.

As a result of this study, the DACS produced a report entitled "Determination of Data Collection Needs for the Ada Program: A Methodology

for Identification and Data Collection." The report presents a generalized methodology for data collection, offers insights needed to apply the methodology effectively, and demonstrates its application to problems of specific interest to Ada data collectors.

10.4 SYSTEM ACQUISITION GUIDELINES FOR THE DESIGN PHASE OF LAYAWAY COMPATIBLE EPCS (AMCCOM - LAMP-F)

This special study was performed for the U.S. Army Armament Research Development Command (AMCCOM) in support of their Layaway and Mobilization for the Future (LAMP-F) program. The objective of the work was to develop a handbook for the acquisition manager who is acquiring systems that must satisfy the requisites of the layaway process.

The layaway process concerns ammunition plants which have been built using electronic process control computers and software. The plants are "laid-away" in peacetime and remobilized when ammunition is needed. This project was designed to ensure that the software which controls the ammunition producing processes is of adequate quality to be maintainable in the long-term future. A large amount of data was collected and was included in the LAMP-F handbook as a case study.

10.5 SOFTWARE QUALITY PREDICTION AND ASSESSMENT

This special study, performed under contract to the Software Engineering Section, Command and Control Division of Rome Air Development Center, developed a relationship between software quality prediction and assessment.

This effort was divided into two parts, the first part being devoted to the development of a methodology for measuring the cost of software quality for the three factors of reliability, flexibility, and maintainability. The second part was directed toward the characterization of the three quality factors in terms of measurable properties exhibited by software during the operations and maintenance phase of the software life cycle. General Research Corporation provided technical support on this effort.

10.6 SOFTWARE QUALITY BENCHMARK

The primary objective of this project performed for the Software Engineering Section, Rome Air Development Center, was to describe a procedure to obtain a software reliability benchmark. Tasks for this study included defining software reliability using operational measures, describing the data needed to develop and validate the reliability value, and developing the procedure for collecting the data and performing the validation. General Research Corporation provided technical support for this effort.

10.7 SOFTWARE ENGINEERING AND ADA LANGUAGE STUDIES

The objective of this project is to support the Battlefield Automation Office of Headquarters, U.S. Army Materiel Command (AMC) by obtaining, analyzing, and evaluating information on activities sponsored by AMC, related to software engineering, and software development and maintenance methodologies.

DACS personnel investigated and evaluated engineering methodologies and tools currently used at Life Cycle Software Engineering (LCSE) centers. The Constructive Cost Model (COCOMO), a tool used to predict the cost of software development and maintenance, was implemented at LCSE centers. DACS personnel then developed the Software Engineering Cost Model (SECOMO), a version of COCOMO which was specifically calibrated and tailored to meet the needs of the LCSE center's applications.

DACS personnel provided training in the use of the model at the various LCSE centers across the country. DACS involvement in this effort led to a DACS report entitled "Calibration of the COCOMO Cost Estimation Model," which explains the methodology used to tailor the model to a particular LCSE application.

10.8 SOFTWARE QUALITY ASSESSMENT FOR THE ACIA SYSTEM

Under contract to the Rome Air Development Center (RADC), Signal Intelligence (SIGINT) Exploitation Section, Intelligence and Reconnaissance

Division, the DACS completed a software quality assessment for the ACIA system.

The objective of this effort was to perform a software quality analysis of the ACIA software system for the purpose of achieving a predetermined quality level. Assessment of the ACIA system was made using automated procedures to perform the data collection and analysis, and manual review of the ACIA source code and documentation.

The desirable quality factors of a software product vary with the needs and priorities of the user. The DACS determined those factors, and identified and classified those characteristics that affect the determined software quality factors.

As a result of this study, the DACS provided RADC with recommendations for achieving the predetermined quality level in the ACIA software.

10.9 DOD-STD-SDS DOCUMENTATION SET

The objective of this effort was to support the Computer Software Management (CSM) subgroup of the Joint Logistics Commanders Joint Policy Coordinating Group on Computer Resource Management (JLC-JPCG-CRM) by analyzing a public review of the Defense System Software Development Standard (SDS) Documentation Set and by producing a revised version.

The primary tasks performed by the DACS were coordination, development and implementation of a current awareness program to inform the DOD and industry of the status and plans for the review of the SDS standards. During the process of transforming the SDS Documentation Set into the new DOD-STD-2167, support consisted of special bulletins. After DOD-STD-2167 was adopted, the DACS continued its support by distributing information on the standard. This project also resulted in a DACS report, "An Overview of DOD-STD-2167," which explains how the new standard was derived and how it is used.

10.10 VALIDATION OF LOGICAL STABILITY METRICS

The objective of this completed study was to collect and analyze software measurements for validating the Logical Stability Metric. This effort was performed for the Software Engineering Section, Command and Control Division of the Rome Air Development Center (RADC).

The Logical Stability Metric is a measure of the resistance of a program to the ripple effect (the propagation of errors after a program modification). The measure is influenced by a program's complexity. Potentially, this measure can be used to indicate the time and effort needed for program maintenance and to identify areas within a program that are sensitive to modification.

Software programs were measured by the logical stability metric, using the ripple effect analyzer tool (developed by Dr. Yau of Northwestern University for RADC), the data flow analyzer, and the program complexity analyzer. A validation plan was developed, which included modifying the programs, collecting data to quantify the modification activities, and analyzing this data against the logical stability metric for the same programs. Experiments were conducted for the tool validation. Several programs were subjected to three test methods; these tests indicated a correlation between the logical stability measures obtained from using the software tools and those measures obtained from the experiments. This was a joint effort with Northwestern University, which provided much of the technical support.

10.11 SDS FRAGMENTS/STRUCTURES

As part of the STARS program, the development of the STARS Software Engineering Environment (STARS-SEE) is intended to provide support across the entire software life cycle and to increase quality and productivity. Under contract to Rome Air Development Center, the DACS provided the STARS Joint Program Office with a background analysis for the STARS-SEE.

This effort included a thorough examination of the software life cycle and its products (data items and data fragments) as specified by DOD-STD-2167, the JLC DIDs and the STARS Measurement DIDs. DACS personnel examined the top-level data items required and developed consistent definitions for fragments into various categories and a mapping of fragments onto life cycle activities.

This effort continued with a second phase, which resulted in a detailed examination of the fragments down to the lowest meaningful level; the classification of fragments according to the previously developed scheme, thus creating a data dictionary; and the analysis of classified fragments in the data dictionary to determine relationships among them, such as redundancy, procedures, and derivability.

10.12 SOFTWARE ENGINEERING FOR STRATEGIC DEFENSE INITIATIVE

The purpose of this project, which was performed under contract to the Rome Air Development Center, Software Engineering Section, Command and Control Division, was to identify software engineering requirements that are responsive to the timeliness and operational performance needs dictated by the goals of the Strategic Defense Initiative (SDI). In particular, the software measurement area was analyzed in detail to determine how it can best address the requirements of Battle Management Software.

Project tasks included precise characterization of the SDI software environment, comprehensive analysis of the state of the art in software engineering technology, identification of SDI-driven technology voids and deficiencies, and detailed review of the software quality measurement area and its application to SDI Battle Management.

10.13 DATA COLLECTION FOR DECISIONS AID SOFTWARE

To support the STARS Program Office in the Measurement Thrust Area, Rome Air Development Center tasked the DACS to provide a comprehensive methodology for the collection of software data.

Software data collection consists of the measurement or monitoring of one or more aspects of the development, operations, or maintenance of a software system. The collection of software data enabled software analysts to predict the cost of software development and maintenance, to verify the requirements originally agreed upon between the customer and software developer, and to determine the best approaches for the development of a software system based on the trends of data collected from past and present software development efforts.

The objective of this effort was to examine an existing Battle Staff Decision Aids software project for the long-range goal of providing a framework that can be used to effectively evaluate the software product and process throughout all phases of the software life cycle.

This study resulted in the assembly of a set of models and software metrics that measured attainment of desired characteristics.

10.14 SYSTEM INTERFACE WITH SIGINT SUPPORT

The objectives of this study completed for the Rome Air Development Center were to analyze the software quality of the Dynamic Ground Target Simulator (DGTS) and the Advanced Sensor Exploitation software systems, with respect to interoperability and reusability; and to determine the feasibility of interfacing these software systems with sensor modeling software.

To meet these objectives, the requirements for coupling the software systems of the DGTS and the SIGINT SYSTEM MODEL (SSM) were determined. Based on Rome Air Developments Center's Software Quality Framework, the software quality factors of interest were identified, and a methodology for assessing these factors was developed.

The feasibility of coupling the software systems was assessed based on the results of the software quality analysis. This study resulted in the recommendation of a specific approach for coupling the systems and in the demonstration of the feasibility of that approach.

The interoperability of DGTS and the SSM modeling systems was accomplished by data coupling the two systems and by reusing existing software programs. The techniques used did not affect the software quality of either systems.

11.0 OBSERVATIONS AND RECOMMENDATIONS

11.1 OBSERVATIONS

During this contract period, the DACS operated as a full-scale IAC, maintaining user interest as reflected in the average monthly receipts of $2,708. The DACS expanded the STINFO and SLED databases and promoted new products and services related to these databases and other special studies. The need for information on software technology continued to increase, which implies the need to continually expand the STINFO database, resulting in up-to-date research materials from which the products and services of the DACS are developed and the availability of the most recent information is supplied to DACS users. An area which relates to the SLED Database is software data collection. Encouraging software developers to collected software life cycle empirical data is becoming a major concern of the DACS. Several special efforts have been initiated to develop guidelines for data collection, and these efforts will serve as a data acquisition vehicle for the expansion of the SLED Database.

Improvements were made during this contract period which included:

- Streamlining data entry procedures for STINFO databases and standardizing tape procedures for SLED datasets, resulting in a significant processing time reduction of data for both of these databases
- Streamlining order-processing procedures to reduce duplication of effort
- Developing software to automate repetitious activities of the DACS databases and office procedures

11.2 RECOMMENDATIONS

The following recommendations are made based on the observations made above and on the activities described during this period.

- Continue to operate and maintain the center based on the goals set for the DACS, and actively pursue new areas of software engineering technology

- Continue to expand the DACS user community through a strong and complete current awareness program
- Conduct special related efforts in order to expand the scope of the DACS
- Continue to expand the DACS STINFO and SLED databases to produce up-to-date research and analysis information from which the DACS can produce products and services that supply the most recent information to DACS users
- Encourage software developers to collect software life cycle empirical data, and continue to pursue the development of guidelines for data collection
- Continue streamlining clerical and administrative procedures concerning the DACS databases and office procedures
- Identify and automate repetitious activities.

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RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control, Communications and Intelligence (C^3I) activities. Technical and engineering support within areas of competence is provided to ESD Program Offices (POs) and other ESD elements to perform effective acquisition of C^3I systems. The areas of technical competence include communications, command and control, battle management, information processing, surveillance sensors, intelligence data collection and handling, solid state sciences, electromagnetics, and propagation, and electronic, maintainability, and compatibility.

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